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THE UNIVERSITY OF ALBERTA

A COGNITIVE ANALYSIS
OF STONE TOOL PRODUCTION

BY

© M. T. Marjolaine Boutin-Sweet

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN
PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

DEPARTMENT OF ANTHROPOLOGY

EDMONTON, ALBERTA

SPRING, 1986

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled: A Cognitive Analysis of Stone Tool Production, submitted by M. T. Marjolaine Boutin-Sweet in partial fulfilment of the requirements for the degree of Master of Arts in Anthropology.

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Date: April 23, 1986

To Doug, and Alec, and the little one. For your patience and understanding, this thesis is dedicated to you.

ABSTRACT

The analysis of stone tools found in archaeological sites can reveal a great deal about the people who made and used the tools. Needless to say, the more information can be gleaned from these tools, the greater our understanding of the people who created them.

The cognitive approach to lithic analysis outlined by Young and Bonnichsen (1984) uses the manufacturing process (as opposed to shape/dimensions data used in the normative approach) to help delineate technological traditions. Because the motor behaviours involved in the making of stone tools become automatic in the accomplished flintknapper, the manufacturing process followedd by an individual, or by a group of craftsmen, is not altered easily nor oten. Thus, manufacturing process is more representative ~~of~~ technological traditions than are typologies based on shape and dimensions of tool alone, traits that can easily be copied by people from different technological traditions.

The development of this cognitive approach and of its methods to a level where it can be widely used by archaeologists involves the gathering of information regarding some morphological aspects of flake scars created by specific flintknapping techniques. Once the analyst knows what to look for on a flake scar, he or she can determine the nature of the technique used to produce each flake scar and the sequencing of those actions. With this type of information, the analyst can recnstruct the process of

manufacture followed by the flintknapper during the making of the tool.

The goal of this thesis is to help gather more information regarding the morphological aspects of flake scars produced by specific techniques. This was achieved in a number of ways. First, an experimental collection made of Knife River flint was analysed, using the methods of the cognitive approach, in order to see what morphological attributes result from specific flintknapping techniques in the context of that raw material. Secondly, these results were compared to those of similar studies conducted on other lithic raw materials. These comparisons revealed that, despite the differences in raw materials, different analysts, some judgement calls, and other such variables, some generalizations can still be made regarding the effects on stone of particular flaking techniques.

In an attempt to understand why such general observations can be made, the third section of this thesis delved into principles related to the behaviour of force waves in solids. The results show that some of these principles could explain why certain flaking techniques result in deeper bulbs of percussion, in more distinctive ribs (ripples), and in a number of other morphological characteristics seen on flake scars. More work on the subject should be conducted by physicists, engineers, or other qualified scientists.

The findings from this approach to lithic analysis serve to make the cognitive approach to lithic analysis more readily usable by archaeologists. The questions it raises should also help promote further research.

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And finally, to my husband Douglas and my son Alec, to whom this thesis is in part dedicated, I wish to say thank you for seeing me through this research. Your patience, support, and your help were more than anyone could ever ask for.

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Chapter I. INTRODUCTION

A) Introduction:

Archaeologists are not uncommonly heard to state that certain flake scars have been produced by a 'hard hammer' or 'soft hammer' technique. That judgement is often based on preconceived ideas of what such flakes should look like and not on first-hand experience. Conventional lithic analysis also involves, for the most part, shape and dimensional attributes that can quite easily be copied. Its use in delineating cultural groups or cultural traditions is therefore limited. Since shape and proportions can be easily copied they may point just as easily to geographical proximity or contact (direct or indirect) with other cultural groups, without cultural, linguistic, or social homogeneity between the groups. A defeated warrior's weapons, for instance, could be copied by the victorious group. On the other hand, a 'mixed' assemblage, so called because the artifacts it comprises exhibit different shapes and dimensions, is most often assumed to be the result of the presence of different groups in the area around the same period of time, or subsequently. But suppose an 'Oxbow' flintknapper simply reproduced a 'Scottsbluff' projectile point he found or saw somewhere else?

Conventional lithic analysis does not provide the tools to answer those questions. Yet when all that remains of a site are bones and stone tools, it is very important to obtain as much information as possible out of the remains if one is to attempt to understand the way of life of the people who occupied the site.

Semenov (1964) used microwear analysis in order to determine how tools were used. Loy recently reported that traces of blood cells and hair still attached to stone artifacts could point to the species of animals hunted or butchered with the tools (1983). The analytical method discussed in this thesis brings us still closer to the people who manufactured the artifacts. It has been called 'cognitive' lithic analysis by its proponents, David E. Young and Robson Bonnichsen, because it determines from an analysis of the manufactured tools, the rules of flintknapping followed by the craftsman. The craftsman's knowledge of flintknapping as organized and stored in his memory cells is reflected by the methods used to manufacture stone tools and by the sequence of those methods. The following section on the cognitive approach explains how the analyst can obtain such information. For now, it is sufficient to say the results of the study of a modern day flintknapper at work, and of the tools he produces, can be applied to the study of archaeological specimens.

7

While shape and dimensions can be copied by someone who has seen the tool, each flintknapper has a preferred way of producing a tool (Young and Bonnichsen, 1984: 23). That preferred way, internalized and habitual in the accomplished flintknapper, is followed even when copying a shape seen elsewhere, or when manufacturing different types of projectile points for different uses, or simply when using different raw materials. This 'preferred way' is simply a set of preferred techniques and their habitual sequencing. Habit has transformed these preferences into the craftsman's rules of flintknapping. Young and Bonnichsen (Idem) refer to such a set of rules as the production "grammar" of an individual flintknapper. Once an accomplished flintknapper has developed a grammar for tool making, he is unlikely to deviate from it significantly.

Using Young and Bonnichsen's cognitive approach, therefore, provides means to answer some of the questions left unanswered by conventional normative (shape-dimensions) lithic analysis: It can determine whether different projectile point types found in a 'mixed' assemblage might not in fact be products of the same production grammar; it can determine whether identically shaped tools found at two different sites were produced by the same craftsmen or by two different groups; it can help distinguish between tools traded into a group and tools made by the group.

Young and Bonnichsen's approach, however, is an intricate one involving many different variables. For that reason there is yet much to be learned, and the approach and methods are constantly being updated as new information is obtained.

B) Research Model

In order to show how the research from this thesis fits into Young and Bonnichsen's cognitive approach as well as in the field of archaeology in general, the following diagram was devised.

RESEARCH MODEL

GOAL:	A: Causal Sequence	(1) Behaviour → (2) Force (in a particular material) → (3) Morphological Attributes
DONE BY:	B: Experimental Collection	a) (1) ← correlation → (3) b) attempt to explain correlations through comparisons (behaviours, tools, force level, raw material), and study of force mechanics
APPLICATIONS:	C: Archaeological Situation	(3) — reconstruction → (1) a) on basis of the results of B (experimental collection) b) by adding (2) (study of the behaviour of force waves in solids), predictions can be made for any raw material

'A' refers to the sequence of events leading to the formation of actual flake scars: (1) the flintknapper uses a particular technological behaviour; (2) this behaviour sends force through the artifact, resulting in (3) the morphological attributes of the flake scar thus created. 'B' summarizes the work done in this thesis, and 'C' refers to the archaeological applications of my research.

The first goal of this thesis is to extend the reference collection by adding the results from the Knife River flint experiments. Several lithic collections have been studied with the help of this cognitive approach. Young and Bonnichsen published the results of their analysis of a Georgetown flint experimental collection (1984); and Pollock used another experimental collection, this one made from Lake Abitibi welded tuff, in his 1984 doctoral dissertation. Each raw material reacts differently to the forces passing through it during flake removal. For that reason, more experimental collections must be produced and studied in order to understand better the morphological attributes created by specific flintknapping techniques or behaviours on stone. Until a way can be found to predict differences in morphological (attribute) outcome from one type of raw material to another (e.g. materials stress tests), many more experimental collections made from a wide range of raw materials should be analyzed in order to make the information on what type of attributes result from certain flaking techniques as complete as possible. The first goal of this research is, therefore, a technical goal.

The second and main goal belongs to the theoretical domain: to relate flake scar attribute morphology to the technological behaviour that produced it (or B : a in the Research Model diagram, above). In order to accomplish this goal, two routes will be taken.

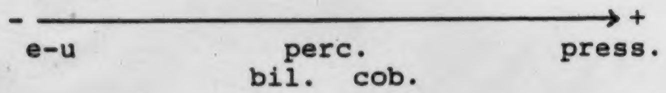
The first route involves generalizations about attributes according to:

a) how the force is delivered (e.g. percussion vs pressure);

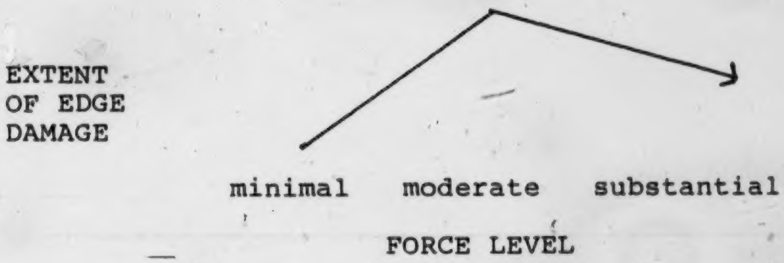
b) changes in degree of perceived force (e.g. from minimal, to moderate, to extensive force levels);

c) raw material

Generalizations regarding the manner in which the force is delivered to the artifact involves comparisons between types of behaviours for a specific attribute. The extent of platform collapse in the Knife River flint experimental collection, for instance, increases from the edge units, to percussion with the billet, to percussion with the cobble, to pressure flaking (see Appendix II).



Generalizations involving changes in the degree of perceived force compare the results for a specific attribute and behaviour at different force levels. In pressure thinning (Knife River flint collection), for instance, the extent of edge damage is least at the minimal force level, more at substantial force, and greatest when moderate levels of force are used.



Generalizations about raw material involve outlining the differences in flake scar attributes resulting from the use of different raw materials, as well as the trends (or correlations between certain behaviours and attributes) perceived regardless of differences in raw material.

The second manner in which this thesis attempts to relate flake scar morphology to technological behaviour is through the investigation of force wave mechanics. Some theories regarding the behaviour of force waves in solids will be explored to try and explain why certain behaviours produce specific morphological attributes on flake scars.

Until now, very little work had been done on the subject. Robson Bonnichsen initially explored this field (1977), and Jill McMahon (University of Maine; no references available) also conducted some research on force mechanics. The work of these individuals did not, however, directly associate force mechanics to technological behaviours, or to morphological attributes. My contribution to the understanding of the relationship between technological behaviour and ensuing flake scar morphology through the study of the force waves travelling through and altering the stone is, therefore, breaking new ground. It is by no means extensive, however, and much more work is required to truly understand what is happening within the stone when a flake is struck off.

As outlined in the Research Model diagram, the archaeological applications of this type of research can be found at two levels. The first level involves a single experimental collection. The results from the analysis of the Knife River flint experimental collection, for instance, could be used to analyse the projectile points from the Muhlbach site (FfPb 100, in central Alberta) which are, for the most part, made of Knife River flint. The identification of the behaviours used to manufacture these tools, and of the sequencing of these behaviours (or 'grammar', see section on the cognitive approach), might show whether the unifacial and the bifacial projectile points from that site could have been made by the same individuals.

Pollock (1984) applied the results of his analysis of the Lake Abitibi welded tuff experimental collection to specific archaeological problems. His task was to discover whether two separate but geographically close archaeological sites, yielding similar artifacts but lacking stratigraphy or other cultural markers, were, in fact, the remains of a single group of people or of two separate groups. Despite the great similarity in shape and size of the artifacts from the two sites, Pollock was able to show, after studying their manufacturing process, that the two assemblages had been produced by different groups. The cognitive approach also helped him solve the problem of whether one of the sites was a multi-component or single component site by showing that some artifacts, exhibiting extreme discrepancies in size, shared the same manufacturing process, and had, therefore, been made by the same people. This latter find demonstrates that tool typologies based on shape and size alone are not enough. As Pollock has shown (Idem.), a typology based on shape and size alone would not have demonstrated the Jordan and Jessup sites had, in fact, been occupied by two different groups of people.

The second level of application of this type of research in archaeology requires the generalizations arrived at by comparing different raw materials, or by studying the behaviour of force waves in solids. General rules regarding the morphological outcome on stone of certain flaking techniques will help the analyst of archaeological artifacts identify the techniques used in the manufacturing of those prehistoric artifacts, regardless of the raw material used by the prehistoric flintknapper.

Either level of application might help solve some of the following archaeological problems regarding the composition of prehistoric groups: how many distinct grammars, and therefore how many individual flintknappers, are represented (through their artifacts at a particular site); was a site occupied by the same group of people over the years (same or similar manufacturing process from one level to the next); were a butchering site and a nearby campsite used by the same group of people? Or, as mentioned earlier, the approach can help distinguish between tools traded into a group and tools made by the group.

C) Cognitive approach

The cognitive approach to lithic analysis is based on the assumption that material products "cannot be understood apart from the processes involved in their creation" (Young and Bonnichsen, 1984: 5). In order to be able to analyse an archaeological artifact properly, one should, therefore, attempt to reconstruct the manufacturing processes that led to its fabrication. In a stone tool this inquiry means finding out what flaking methods were used by the maker of the tool and in what order. These methods are referred to by Young and Bonnichsen as 'behaviours', and the order in which they are used as the 'sequencing of behaviours'.

The nature of the behaviours used on a prehistoric stone artifact is not obvious to the untrained eye. These behaviours are identified through cognitive research. The process of cognitive lithic analysis is as follows. A modern day flintknapper is asked to remove flakes from an experimental biface collection, using one of a number of different behaviours repeatedly on one side of a biface (e.g. he may be asked to remove thinning flakes using the pressure technique and a moderate amount of force). The entire process is recorded on videotape for use later during the analysis. The flake scars resulting from each flaking behaviour are then studied to see if their morphology is characteristic enough to permit positive identification of each type of behaviour. The results of this study can then be transposed to the archaeological artifacts, and behaviour identification can be done from a more knowledgeable standpoint. Since the nature of the raw material affects the morphology of flake scars, one must use an experimental collection made of the same raw material as the prehistoric artifacts studied.

This research project involved the analysis of a particular experimental collection (made from Knife River flint) and the comparison of the results to those of other experimental collections in order to determine whether some morphological characteristics could be associated with certain behaviours, regardless of raw material. Explanations for these general observations were also sought. Obtaining this information is part of the natural process of development of the cognitive approach to lithic analysis. A more extensive summary of this cognitive approach to the analysis of stone tools can be found in Young and Bonnichsen (1984).

D) Problems

1) Problems with the approach

Young and Bonnichsen's cognitive approach involves the use of a complex terminology for describing in detail the processes of flake removal and of stone tool production (see glossary). This long list of terms, once it is well understood, helps the analyst get a clear picture of the flintknapper's options, his actions, and the results of such actions. But first, all the definitions must be assimilated by the analyst. This procedure may take some time, and Young and Bonnichsen's cognitive approach cannot be used properly until one is well versed in the subject.

The terminological barrier often prevents first-time readers from quickly understanding the approach, its process, and results. Lack of understanding unfortunately often leads to dismissal of the entire concept, which, with somewhat more effort on the part of the reader, might otherwise have been accepted.

Furthermore, this approach to lithic analysis challenges the conventional shape-dimensions approach, referred to as 'normative' by Young and Bonnichsen (1984: 3), still used by most archaeologists. Resistance to change, a topic so well studied by anthropologists, permeates their own ranks, making it more difficult for new approaches to be easily accepted.

2) Problems with the methods

As will be seen in chapter I.E) on methodology, this approach requires time-consuming preparation, intricate coding, and lengthy analysis. The photography, for example, requires time and skill in order to obtain detailed photographs of the quality required for the analysis of the artifacts they depict. The photographer must ensure every square centimetre of the artifact is in focus, and every flake scar properly highlighted by the right combination of lighting and shading. Similarly, the coding of each artifact takes time: 14 attributes were recorded for each of the 2 to 25 flake scars from each of the 31 experimental behaviours of the Knife River flint experimental collection!

One should also be familiar with the process of flintknapping. It is difficult, for example, to determine which flakes are a success and which ones are failures when one does not know how flakes removed by a particular technique should appear. A substantial percussion thinning flake, for instance, should be quite large and extend well beyond the platform area onto the surface of the artifact.

Although the interpretation of specific attributes should be standardized, some variation is to be expected even if the entire analysis is conducted by a computer. One analyst may be able to see more detail than another, and thus find more ribs, microflakes, and so forth.

This type of analysis is also more expensive than the normative type. Ongoing costs such as photographic prints, videotapes, coding sheets, and computer time are added to the cost of the basic equipment (photography, coating device, stereo viewer, video camera, and playback equipment).

Certain techniques, not yet used by those who have espoused this cognitive approach to lithic analysis, could alleviate and even eliminate some of the aforementioned problems. A rather sophisticated video system informally known as 'video imagery' or 'photogrammetry' (personal communication, Gary Robertson, Robertson Photogrammetric Inc., Edmonton, Alberta, fall 1982) can record a three-dimensional image of an artifact by scanning it with a video camera and recording X, Y, and Z co-ordinates at predetermined intervals, as close to each other as 0.1 micron. The advantages of such a system are numerous:

1. It would replace the lengthy, complex, and expensive process of photography.
2. It would produce perfect three-dimensional images of the artifacts, without out-of-focus or washed-out areas.
3. The recorded X, Y, and Z coordinates could be fed directly into the computer.
4. Combining this data with a programme capable of comparing each archaeological flake scar to a series of experimental flake scars in order to determine how the archaeological flake scar was produced would help standardize the coding process and considerably reduce the time spent on analysis.

The equipment used by the 'video imagery system' is, however, quite costly. Furthermore, there are computer space problems caused by the fact that digitizing the entire surface of a single artifact involves an incredibly large amount of data. This situation precludes the analysis of an entire assemblage, unless there is a great deal of computer memory and storage available to the researcher.

As the state of technology progresses, new techniques will surely standardize and speed up the process of 'cognitive lithic analysis'.

E) Methodology

1) Knife River flint experimental collection

The raw material, Knife River flint, was originally chosen because it made up 87% of a collection of prehistoric artifacts which was to be analysed as part of the research for this thesis. The original idea was later dropped, but the Knife River flint experimental collection was kept and analysed.

After several conversations with Canadian and American archaeologists it became clear the only source of good quality Knife River flint is located in North Dakota. Several nodules of the material were obtained through the courtesy of Dr. Stanley Ahler of the Department of Archaeology and Anthropology at the University of North Dakota, Grand Forks, North Dakota.

While the flintknapper, Robson Bonnichsen, prepared a number of preforms, a list of 31 behaviours was prepared by David Young and myself (see Table I-1). These are the behaviours represented in the Knife River flint experimental collection. Before the flintknapping experiment began, the preforms were coated with white paint in order to achieve better contrast between the flake scars and the unflaked surface of the artifact.

The production of flake scars from all 31 behaviours was videotaped by the Radio and Television Department of the University of Alberta. In most cases a single behaviour was used to create a series of flakes on one edge of a preform. Each preform edge was given a number associated with the behaviour exemplified on it.-1- While being videotaped Bonnichsen offered comments, sometimes in response to questions by Young, about his aim, technique, results, and other relevant matters. The information obtained from the videotape was later transferred to a Table (Table II-34) to be used during analysis of the flake scars. The catalogued experimental artifacts were cursorily drawn and bagged along with the flakes issued from them (where possible).

The next phase involved photographing all experimental artifacts. Enlarged stereo photographs were used for the analysis in order to provide greater detail and to create a permanent record of what the analyst saw and recorded. The use of stereo photographs in conjunction with a stereo viewer (see Fig. 1) allows one to see a three-dimensional image of the artifact, a representation which greatly facilitates analysis. Knife River flint is a somewhat translucent material which allows some of the below-the-surface patterning to obscure the surface detail. In order to resolve this problem, a thin coat of ammonium chloride was applied to the artifacts before photography. This coating served to conceal the internal detail without obscuring the surface morphology of the flake scars. The coated artifact was set on a tilting stage within a white translucent plexiglass box designed to diffuse the light and make it as uniform as possible across the entire surface of the artifact (Fig. 2). Small lamps set out in specific areas around the perimeter of the white box were used to highlight the artifacts' features through a combination of lighting and shading. The distance between camera and tilting stage remained constant throughout all photographic sessions in order to retain the same scale. Copious notes were taken regarding the exposure, tilting angle, frame number, artifact number, and other photographic conditions. Appendix III describes the photographic aspect of this research in greater detail.

A drawing of the two faces of each experimental artifact with the delineated flake scars was made from the photographs on transparent acetate sheets. These drawings can be laid over the photographs (Fig. 3) in order to show the exact location and shape of each of the analysed flake scars. From these drawings another drawing was made, on paper, to be used by the analyst as a work sheet (see Fig. 4) for coding purposes. On it the scars were numbered and divided into analysable and non-analysable scars.

The coding itself was done using the stereo photographs, stereo viewer, artifacts, magnifying glass where required, work sheets, coding sheets, and notes from the videotape. Fourteen characteristics (attributes) from each analysable flake scar were evaluated and their state or value noted on the coding forms (see Table 1 and Figure 5). Some of the original attributes and attribute states or values drawn from previous cognitive lithic analyses (Pollock, 1984: 175-177, Table 13) were altered or dropped and new ones were introduced during the course of the coding process.

The coded information was summarized in a number of ways. In Table I-2, for instance, a composite picture of the characteristics of flake scars from each behaviour was built from the percentages of each attribute state (value) observed for that behaviour. The guidelines which were followed in drawing such a composite picture are outlined in Table I-3. The percentages are those of the values found on all the analysable flake scars from each behaviour. The analysis of the proximal edge morphology (see attribute #2.4 in Table 1) of minimal pressure shaping flakes, for example, yields 46% flat curves, 31% straight, and 23% irregular proximal edges (see artifact #9i, attribute #2.4, Table I-2).

The next step in the analysis of the Knife River flint experimental collection was to extract the trends recognized among all that information, the similarities and differences between certain behaviours, the links between sets of attributes, and to attempt to explain as many of these as possible (see Appendix II.B and chapter II).

The Knife River flint experimental collection is stored with the Project for the Study of Material Culture, Department of Anthropology, University of Alberta, Edmonton, Alberta.

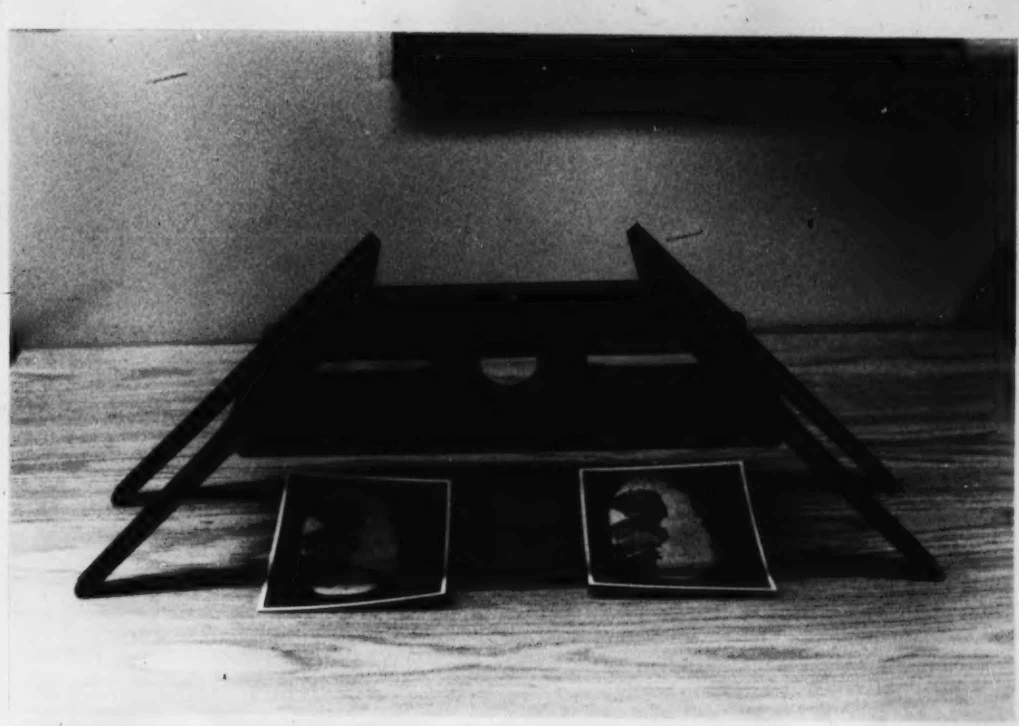


Figure 1. Stereo Viewer

Figure 2. Photographic Equipment

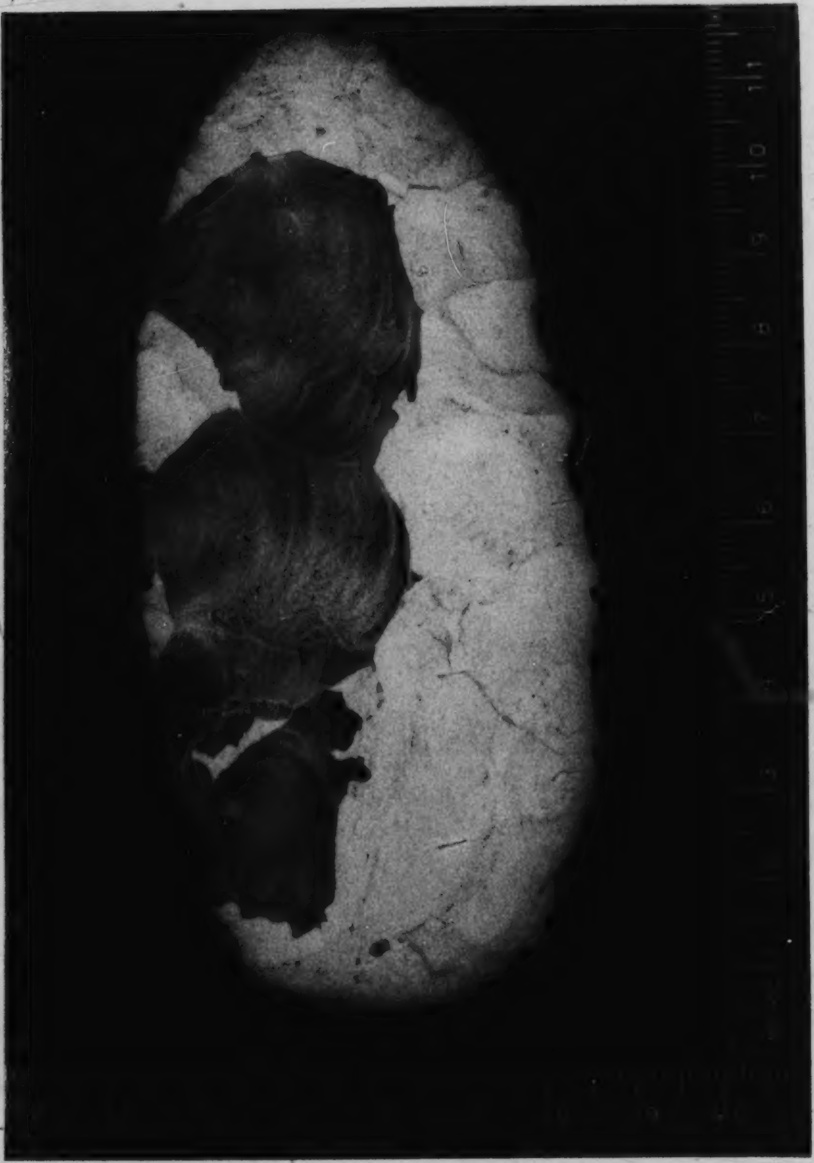


Figure 3. Artifact #K1-11(14)-1: Side 14
Substantial Percussion Thinning
with Cobble

Artifact #K1-11(14)-1

(Side 14)

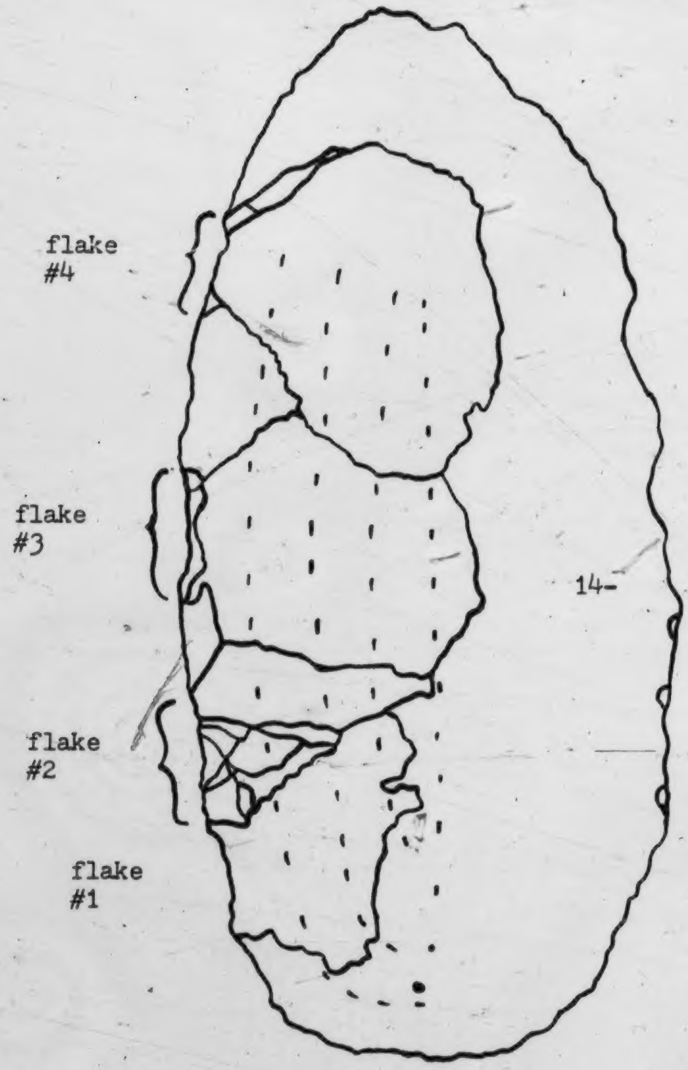

flake #4
flake #3
14-
flake #2
flake #1

Figure 4. Work Sheet

KNIFE RIVER FLINT EXPERIMENTAL ARTIFACTS

K1-________:		Flake Scar #			%
1.0 Flake Scar Size Attributes:					
1.1 flake scar size:					
2.0 Flake Scar Proximal Edge Attributes:					
2.1 edge sharpness:					
2.2 proximal margin damage:					
2.3 microflakes:					
2.4 edge morphology: 2.5 platform collapse:					
3.0 Flake Scar Profile Attributes:					
3.1 distinctiveness of bulb:					
3.2 bulb size:					
4.0 Flake Scar Interior Morphology Attributes:					
4.1 ribs: presence:					
4.2 ribs: distinctiveness:					
4.3 ribs: spacing:					
4.4 tearing:					
5.0 Flake Scar Distal Edge Attributes:					
5.1 shape:					
5.2 termination:					

Figure 5. Coding Form

TABLE 1

MORPHOLOGICAL ATTRIBUTES AND ATTRIBUTE STATES USED TO DESCRIBE INDIVIDUAL FLAKE SCARS

(after Pollock 1984, Young 1984)

1.0 Flake Scar Size Attributes

1.1 Flake Scar Size (based on a ratio between the length of the flake scar and the maximum width of the artifact; measured from the point of force application):

- 1.1.1 Very Minimal (less than 1/8 maximum width)
- 1.1.2 Minimal (1/8 - 1/4 maximum width)
- 1.1.3 Moderate (1/4 - 3/8 maximum width)
- 1.1.4 Substantial (3/8 - 1/2 maximum width)
- 1.1.5 Very substantial (greater than 1/2 maximum width)

2.0 Flake Scar Proximal Edge Attributes

2.1 Sharpness of Proximal Edge (based on tactile test):

- 2.1.1 Sharp
- 2.1.2 Intermediate
- 2.1.3 Dull

2.2 Proximal margin damage (stepping, hinging, imbedded flakes and/or shattering along margin or proximal edge due to initial application of force):

- 2.2.1 Absent or rare (0 - 10%)
- 2.2.2 Limited (10- 25%)
- 2.2.3 Moderate (25 - 50%)
- 2.2.4 Extensive (50 - 75%)
- 2.2.5 Very extensive (75 - 100%)

2.3 Microflake scars on Proximal Edge (a series of tiny edge indentations produced by the same action that removed the primary flake):

- 2.3.1 Absent or rare (0-10%)
- 2.3.2 Limited (10-25%)
- 2.3.3 Moderate (25-50%)
- 2.3.4 Extensive (50-75%)
- 2.3.5. Very extensive (75-100%)

cont'd

2.4 Morphology of Proximal Edge of Flake Scar (resulting from the type and extent of force applied when the flake is removed)

- 2.4.1 Edge relatively straight (can be smooth or rough). No noticeable platform collapse
- 2.4.2 Distinct U-shaped notch
- 2.4.3 Notch is a flat curve
- 2.4.4 Edge not notched but contains distinct convex projections
- 2.4.5 Other

2.5 Platform collapse (whether any portion of the platform was removed)

- 2.5.1 Present
- 2.5.2 Absent
- 2.5.3 Partial

3.0 Flake Scar Profile Attributes

3.1 Distinctiveness of Bulb (based on tactile test)

- 3.1.1 Not Applicable
- 3.1.2 Not visible
- 3.1.3 Intermediate
- 3.1.4 Distinct

3.2 Bulb Size (ratio of bulb length to max. length of flake scar)

- 3.2.1 Very minimal (less than 1/8 max. length)
- 3.2.2 Minimal (1/8 - 1/4 max. length)
- 3.2.3 Moderate (1/4 - 3/8 max. length)
- 3.2.4 Substantial (3/8 - 1/2 max. length)
- 3.2.5 Very substantial (greater than 1/2 max. length)
- 3.2.6 Not applicable

4.0 Flake Scar Interior Morphology Attributes

4.1 Ribs (waves extending toward distal edge from platform)

- 4.1.1 Absent or rare (ribs occur in 0-10% of all flake scars produced by a given behavior unit)
- 4.1.2 Limited (10-25%)
- 4.1.3 Moderate (25-50%)
- 4.1.4 Extensive (50-75%)
- 4.1.5 Very extensive (75-100%)

4.2 Distinctiveness of Ribs

- 4.2.1 Not applicable
- 4.2.2 Indistinct
- 4.2.3 Moderately distinct
- 4.2.4 Pronounced
- 4.2.5 Variable on same flake scar

cont'd

4.3 Rib Spacing

- 4.3.1 Not applicable
- 4.3.2 Relatively far apart and fairly evenly distributed across flake scar
- 4.3.3 Relatively far apart and found primarily on distal half of flake scar
- 4.3.4 Relatively close together and evenly distributed across flake scar
- 4.3.5 Relatively close together and found primarily on distal half of flake scar
- 4.3.6 Variable on same flake scar
- 4.3.7 Other

4.4 Tearing (a mass of short but parallel lines concentrated along or near the margins of the flake scar)

- 4.4.1 Absent or rare (occur in 0-10% of all flake scars)
- 4.4.2 Limited (10-25%)
- 4.4.3 Moderate (25-50%)
- 4.4.4 Extensive (50-75%)
- 4.4.5 Very Extensive (75-100%)

5.0 Flake Scar Distal Edge Attributes

5.1 Flake Scar Shape at Distal Edge

- 5.1.1 Scar terminates in relatively straight distal edge
- 5.1.2 Scar terminates in relatively rounded distal edge
- 5.1.3 Scar terminates in irregular distal edge

5.2 Flake Scar Termination (relation between fracture surface and original surface at distal end of flake scar):

- 5.2.1 Feather termination
- 5.2.2 Step termination

Chapter II. SUMMARY OF MORPHOLOGICAL FINDS

A) Knife River flint experimental collection

SECTION 1: ATTRIBUTES

(see Appendix II, B) for greater detail)

(1) Edge damage

Any stepping, hinging, shattering, or imbedded flakes (see glossary) observed along the margin of a flake scar's proximal edge is referred to as edge damage or as proximal margin damage (see attribute #2.2 in Table 1).

The frequency with which edge damage is seen on flake scars increases from pressure flaking to the edge unit behaviours, to percussion with the cobble, to percussion with the billet. The shaping flake scars exhibit edge damage more often than do the thinning flake scars. The frequency of edge damage appears to increase with the use of greater force in removing a flake, in 43% to 57% of behaviours. Edge damage frequency also appears to be associated with platform collapse, bulb distinctiveness (i.e. presence/absence), and with the number of attempts needed before a successful flake is removed. The more often the flintknapper has to hit the biface, or apply pressure, in order to remove a flake of the desired shape, the greater the chances of some damage on the flake scar's margin. The amount of force used also affects the frequency of edge damage, as it does the frequency of bulb presence or visibility. Once there is too much damage, however, bulb visibility is affected; and its frequency no longer follows that of the margin damage. The collapse of the platform area removes some of the damage. As has been demonstrated, the results from these two attributes show inverse ratios: the greater the platform collapse, the lesser the frequency of margin damage, and vice-versa.

(2) Platform collapse

Most flake scars show some removal of material in the platform area. The extent of this platform collapse is reflected by the morphology of the proximal edge (attribute 2.4 in Table 1).

The edge units produce the least amount of platform collapse, the pressure units the most. Percussion ranks in the middle with the cobble causing more collapse than the billet. This is seemingly the result of the amount of force required by each behaviour to remove the same amount of material (e.g. at the moderate force level in pressure, 71% if the flake scars have (flat-) curved proximal edge; while 59% of the flakes in percussion with cobble (same force level) show the same curvature, and only 29% of the flakes removed with the billet do so. ~~Th~~eoretically, the shaping behaviours, because of what they attempt to do (remove material from the edge of the preform), should exhibit more platform collapse than the thinning behaviours. Because of the overlapping of the shaping flakes, however, evidence of platform collapse is removed and the shaping flakes appear to undergo less collapse than the thinning flakes. In most cases, the extent of platform collapse increases with the amount of force used in removing a flake. As seen above, platform collapse is associated with edge damage in that the greater the amount of the platform removed, the less frequently is edge damage seen.

(3) Ribs

The ribs, (ripples or waves), that extend from the proximal to the distal edge of a flake and that are perpendicular to the direction of the force, may or may not be visible. When visible, their size (distinctiveness of ribs: attribute #4.2 in Table 1) and location (rib spacing: attribute #4.3 in Table 1) may vary.

The frequency with which ribs are seen is difficult to assess; it may increase from the edge unit behaviours, to percussion with the billet, to pressure, to percussion with the cobble. Thinning produces ribs more often than shaping. In most cases, an increase in force level also results in greater frequencies of ribs. It may be noted the same phenomenon applies to the bulb of force.

Except for pressure flaking, which produces the least distinctive ribs, rib size increases from edge units, to percussion with the billet, to percussion with the cobble, as does rib presence frequencies. The distinctiveness of the ribs does not increase with the application of increased amounts of force (force increase affects each type of behaviour differently), although it appears that rib distinctiveness and bulb distinctiveness are associated.

While flakes removed by percussion with the billet show a preponderance of ribs that are closely spaced and located on the distal half of the flake scar, the flakes removed by the other methods show relatively even distributions of closely spaced ribs located on the distal half or on the entire surface of the flake scar, outside the bulb of force. No distinction can be made between the thinning behaviours, as both exhibit fairly even numbers of ribs that are located on the distal half and of ribs that are evenly spaced across the flake scar. An increase in force level does not affect the location of ribs in percussion with the billet, or in the edge unit flakes; but in pressure flaking and in percussion with the cobble there is a slight tendency towards ribs that are more evenly distributed on the flake scar as the force level is increased. That is to say, an increase in force level is accompanied by a slight decrease in the prevalence of ribs located solely on the distal half of the flake scar, and by a slight increase in the occurrence of ribs that are evenly distributed across the entire flake scar (outside the bulb of force).

(4) Bulb of percussion or bulb of force

The bulb (attributes #3.1 and 3.2 in Table 1), a conical indentation of variable size at the proximal end of the flake scar, is not always visible, or certainly not always distinctive. When it terminates in a gradual slope, its size is difficult to ascertain.

Bulbs of force were found more often on flakes created by a percussion behaviour, particularly one that uses a cobble as a percussor; less often in pressure flaking; and least often in the edge units flake scars. The shaping and thinning units are fairly similar when it comes to bulb presence or absence, although the thinning techniques do show a few more bulbs. As for the presence of ribs, the greater the force used in removing a flake, the greater the chance of seeing a bulb of force. As stated earlier, because increased force also occasions more edge damage, an increase in bulb frequency is usually associated with edge damage, until the extent of edge damage is at its greatest and interferes with our ablity to see the bulb.

The size of the bulb is also greatest in percussion flakes, less in pressure flakes, and least in the edge unit flake scars. The billet and the cobble appear to create bulbs of a similar size, as do the thinning and shaping behaviours (although shaping flakes exhibit slightly larger bulbs, on the average). Unlike the presence of the bulb, however, bulb size does not increase with the use of greater force by the flintknapper. The same phenomenon was observed earlier for rib presence and rib size or distinctiveness.

(5) Distal shape

Flake scar shape at distal edge (attribute #5.1 in Table 1) simply refers to the shape of the end of the flake scar.

An irregular distal edge was the type found most often, except in the edge unit flakes and those created by percussion shaping with the billet. An interesting observation, however, is that the frequencies for this distal shape type appear to dwindle as force is increased. The application of greater force by the flintknapper appears, therefore, to regularize the shape of the flake's distal edge. The irregular distal edge also appears to be more common on the thinning than on the shaping flakes. The straight distal edges are found most often on the pressure flakes, and the rounded distal edges are more common on percussion and edge unit flake scars than on those created by pressure flaking.

The shape of the distal edge of a flake scar is associated with the type of termination (see below) seen on that same flake scar. The flakes exhibiting an irregular distal edge show termination ratios of 2:1 in favour of the feathered type. Feathered terminations also predominatee over step terminations by a ratio of 4:1 in the case of the rounded distal edges. The flake scars ending in a straight edge, on the other hand, were found to terminate abruptly (i.e. step termination) in 60% of cases (or a 3:2 ratio of step to feathered terminations).

(6) Termination

The flake scar termination (see attribute #5.2 in Table 1) refers to the slope of the distal edge of the flake scar. A gentle, gradual slope is termed 'feathered', while an abrupt, steep ending to the flake scar is called a 'step' termination.

Percussion with the billet results in feathered terminations more often than in step terminations. In pressure shaping and percussion shaping with the cobble, the feathered terminations also dominate; but with pressure thinning and percussion thinning with the cobble, step terminations are at least as common as the feathered type. The shaping behaviours in general show a large predominance of feathered terminations, while the thinning behaviours (with the exception of billet work) exhibit step terminations more often. Step terminations are also the more common found type on the edge unit flakes. An increase in force level seemed to affect three types of behaviours only: in pressure thinning it increased the incidence of step terminations; and in percussion shaping with the billet, and to a lesser extent, in the shearing units, it reduced the abruptness of the slope, yielding more feathered terminations.

As seen above (see (5) Distal shape), step terminations are most often associated with straight distal edges while the featheered type is predominantly found on flake scars displaying a rounded, or an irregular distal edge.

SECTION 2: BEHAVIOURS

(see Appendix II, B) for greater detail)

(1) Edge units

The edge units are limited to the very edges of the worked biface or artifact. These include the shearing behaviours (shear thin, shear shape), the rubbing behaviours (rub abrade, rub buffet with billet or cobble, and pressure rub), and 'edge press on anvil' (for a description of each method see glossary).

The edge units show the least amount of platform collapse, lowest frequencies of ribs presence and of bulb presence, the smallest bulbs (relative to flake scar size), and ribs whose distinctiveness (or size) exceeds only that of the ribs seen on pressure flakes. These ribs are found equally often on the distal half or on the entire flake scar (outside the bulb of force). The frequency of edge damage ranges between that of the percussion and pressure behaviours and, is moderate to extensive or less. The distal shape of the flake scars created by an edge unit is rounded in 44% of cases, straight in 30%, and irregular in the remaining 26% of cases. Accordingly, these flakes end in a feathered termination 62% of the time. In shearing, the only edge unit technique where different force levels are used, increased force extends the amount of platform collapse, and the frequency of ribs presence and of bulb presence, as well as the frequency of feathered terminations. The same increase in force reduces slightly the distinctiveness of the ribs. Increased force appears to have no effect on edge damage frequencies, location of the ribs, and size of the bulb of force.

As demonstrated in Appendix II B, the edge unit behaviours form a more tightly knit grouping than do the pressure or percussion behaviours. That is to say, the morphological characteristics produced on flake scars by the edge unit techniques show a high degree of similarity from one behaviour to the next.

As a group, and on the basis of flake scars' morphological attribute states, the edge units are closer to the pressure units than they are to the percussion units.

(2) Pressure

Flake scars produced by the pressure technique display the lowest frequencies of edge damage, and the least distinctive ribs. Pressure, on the other hand, also yields the greatest extent of platform collapse. Ribs are seen quite frequently: the frequency of rib presence on pressure flakes is surpassed only by the frequency of ribs on flakes removed by the percussion with cobble technique. As in the case of the edge units, the ribs are found equally as frequently on the distal half of the flake scar as they are on the entire surface of the flake scar (outside the bulb of force). The bulb of force is present more often than on the edge unit flakes but less so than on the percussion flakes, particularly those removed with the help of the cobble. Its size is proportionally larger than the size of bulbs created by edge unit techniques. Pressure and percussion, however, yield bulbs of a comparable size. The distal edge of pressure flake scars is irregular in 50% of cases, straight in 31%, and rounded in 19% of cases. The type of termination varies widely depending on whether pressure is used to shape a biface or to thin it: in the thinning flakes, step terminations greatly outweigh the feathered type, while in the shaping flakes, feathered terminations are found almost exclusively.

An increase in force level in pressure causes more platform collapse, a greater chance of seeing ribs and a bulb of force, ribs that spread out more evenly across the flake scar, more regular distal edge shapes (more straight edges than rounded), and an associated increase in the frequency of step terminations. Edge damage, rib distinctiveness, and bulb size also increase in some cases, but remain the same in others, when the force is increased.

The pressure behaviours show less cohesion among themselves than do the edge units, but more than do the percussion units. This information is based on the morphological outcome of the flake scars issued from each of the three technological groupings (pressure, percussion, edge units). Again, from a morphological perspective, the pressure behaviours are closer to the edge units than they are to the percussion behaviours.

(3) Percussion

The characteristics that apply equally well to billet and to cobble percussion will be summarized here under the general category of percussion. The attributes whose values differ depending on whether the billet or cobble is used will be treated separately (see below).

The flake scars resulting from a percussion behaviour show the highest frequencies of edge damage and of bulb presence, and the most distinctive ribs. Billet work leaves more edge damage than the cobble, but the cobble creates bulbs more often, and larger (more distinctive) ribs. Percussion techniques also result in less platform collapse than for pressure shaping but more than for the edge units. The cobble appears to remove more of the platform than does the billet. The size of the bulb is, proportionally, larger than the size of bulbs seen on edge unit flake scars and, perhaps, slightly larger than that of bulbs produced by the pressure technique. Generally speaking, however, the range of bulb sizes from pressure, percussion with billet, and percussion with cobble flake scars greatly overlap. An increase in the amount of force used in producing percussion flakes results in higher frequencies of edge damage (except for shaping with the cobble where edge damage becomes less frequent), and of bulb presence, as well as in a greater extent of platform collapse (except in the case of shaping with the billet). The effect of increased force on the distinctiveness of the ribs and on the size of the bulb varies.

Billet

Percussion with the billet produces ribs more often than do the edge units but less often than do pressure or percussion with the cobble. The ribs that appear on flake scars created by billet percussion are located on the distal half of the scar in 90% of cases. Rounded and irregular distal edges are found most often, the rounded type being associated more with the shaping flakes than with the thinning flakes. The flakes terminate in a gentle slope (feathered) in 58% of cases, a perhaps slightly low percentage when one considers that irregular and rounded distal shape types, the types associated approximately 70% of the time with feathered terminations, appear on 87% of the billet percussion flake scars. An increase in force level generally tends to produce ribs more often, as well as gentler terminations (feathered) on the shaping flakes. The location (spacing) of the ribs is not affected by an increase in force. When thinning flakes are being removed with the help of the billet, the addition of force tends to produce flake scars that are less irregular or more rounded at their distal edge. The shaping flakes exhibit rounded distal edges in the majority of cases and regardless of the amount of force used.

Cobble

Percussion with the cobble produces ribs more often than any of the other behaviours. These ribs may be found on the distal half or on the entire flake scar (outside the bulb of percussion), unlike the ribs produced by billet percussion which are found mainly on the distal half of the scars. Irregular distal shapes are most common, although the rounded type follows closely behind. Straight distal edges account for only 10% of the flake scars created by percussion with the cobble. Feathered terminations generally predominate over step terminations (71%:29%), although in the thinning flakes, the step terminations are at least as common as the feathered type. An increase in force level increases the chance of seeing ribs, and spreads these ribs more evenly across the flake scar. As in the percussion with billet behaviours, an increase in force while using the cobble produces more rounded and less irregular distal edges on thinning flakes, but does not affect the high frequencies of rounded distal edges found on shaping flakes. The type of termination does not appear to be much affected by force increase.

The percussion group of behaviours shows the lowest degree of internal cohesion based on shared morphological traits. Its internal cohesion index (see Appendix II, B) Section 1, Subsection 3 (5) d)), is, however, still higher than its inter-group similarity indices, a fact that vouches for its validity as a separate technological grouping. On the basis of morphology of produced flake scars, the percussion group has closer ties to pressure than it has to the edge units.

(4) Thinning vs Shaping

The thinning behaviours create slightly more edge damage, more visible (or apparent) platform collapse, greater frequencies of ribs that are also more distinct, and possibly higher bulb presence frequencies. The flakes' distal shape is irregular most often, but can also be rounded or straight. Step terminations are at least as common as the feathered type.

The shaping flakes exhibit bulbs that are slightly larger than those seen on thinning flakes, rounded distal shapes that predominate over the irregular type, and a high frequency of feathered terminations.

Both types of behaviours show similar frequencies of ribs located on the distal half and of ribs spread out evenly across the flake scar. In the shaping units, however, an increase in force tends to produce ribs that are more often found across the entire flake scar than on the distal half alone.

B) Lake Abitibi welded tuff experimental collection

(see Table I-4)

In his doctoral dissertation, John Pollock (1984) applied Young and Bonnichsen's cognitive approach to the analysis of lithic artifacts from the Jordan and Jessup archaeological sites in northeastern Ontario. The raw material from which these artifacts were manufactured is referred to by Pollock as Lake Abitibi welded tuff. Unworked nodules of the material were sent to Robson Bonnichsen and an experimental collection, similar to that described earlier for the Knife River flint material, was created in order to provide the basis upon which the Lake Abitibi prehistoric artifacts could be analysed. The following summarizes the results of Pollock's morphological analysis of the Lake Abitibi welded tuff experimental collection (Ibid.: 185-193) in terms similar to those used for the Knife River flint experimental collection.

SECTION 1: ATTRIBUTES

Edge damage is seen 25% to 100% of the time (moderate to very extensive) on flakes created by percussion, but only 10% to 50% of the time (limited to moderate) on pressure flakes. Frequencies for percussion with the cobble are identical to those of billet percussion.

According to Pollock, the proximal edge of flake scars resulting from cobble or billet percussion is characterized by a flat curve. In pressure, however, the proximal flake scar's edge usually takes the form of a U-shaped notch. Platform collapse is, therefore, more extensive in pressure than in percussion flaking, and approximately the same for the flakes removed by billet or cobble percussion.

As was the case in the Knife River flint experimental collection, the welded tuff specimens also show a correlation between edge damage and platform collapse: the greater the extent of platform collapse, the lesser the chance of seeing some edge damage on the flake scar. Again, the removal of some of the platform area appears to remove evidence of edge damage.

The bulb of force was difficult to detect on flakes from all three types of behaviours (pressure, percussion with billet, percussion with cobble). When distinct, it appeared to be longest and deepest on percussion with billet flake scars.

Ribs, like the bulb, were seldom seen on the welded tuff bifaces. The use of the antler billet produced ribs most often (up to 50% of the time; or absent to moderate frequencies of rib presence), followed by percussion with the cobble (absent or limited frequencies: 0 to 25% of flake scars), and by pressure flaking (absent or rare: 0 to 10% of flake scars). Regardless of frequency or of tool used, the ribs seen on welded tuff experimental artifacts were for the most part indistinct. In pressure flaking, the ribs are mostly close together and spread out over the entire surface of the flake (outside the bulb of force). In percussion with the billet, the ribs are not so close together and can be seen mainly on the distal half of the flake scar. Pollock adds that two distinct ridges are often seen near the distal edge of the scar (Ibid.: 187). The ribs seen on flake scars created by percussion with the cobble are also far apart, but they are evenly distributed across the entire flake scar (outside the bulb of force). Thus it appears each method produces different results with respect to the spacing of ribs when these are present on a flake scar.

The shape of the distal edge of the flake scars also varies from one technological group to the next. Pressure flaking produces mostly rounded distal edges, while percussion with the cobble results in straight distal edges in the majority of cases, and flakes removed by billet percussion yield similar frequencies of straight and rounded distal edges. Overall, the straight edge seems to be the most common type found, and the irregular edge the most infrequent.

The pressure technique results in feathered terminations more often than in step terminations, while percussion with the cobble causes much more abrupt (step) terminations. The flakes removed by billet percussion show equal ratios of feathered and step terminations.

SECTION 2: BEHAVIOURS

(1) Pressure

When pressure is applied to preforms made of the Lake Abitibi welded tuff, much platform collapse is observed, but less edge damage results than in percussion flaking. The bulb of force is infrequently seen on any type of flake. Ribs are also seldom seen and, when they are, are faint (indistinct), close together, and evenly distributed across the flake scar. The flake scar usually terminates in a rounded and feathered fashion, although some straight and irregular distal edges are also found, as well as some abrupt step terminations.

(2) Percussion

The percussion technique produces less platform collapse and more edge damage than the pressure technique. Ribs are present somewhat more often in percussion than in pressure flaking, particularly when the antler billet is used. The ribs are no more distinct in percussion than in pressure, however (indistinct in both cases).

a) billet

Percussion with the billet creates bulbs that, when distinct, are the longest and deepest. They are not distinct very often, however. It also produces ribs more often than the other two methods. These ribs are found mostly on the distal half of the flake scar, and are relatively far apart. Two larger ribs are often seen near the distal edge of the scar, which may be either rounded or straight. The flake correspondingly terminates in a gentle slope (feathered) some of the time, and in a step the remainder of the time.

b) cobble

Percussion with the cobble, following the same pattern as the other types of behaviours, does not yield bulbs of force very often. Rib frequencies are also quite low (absent or limited), although somewhat higher than those seen for pressure flaking (absent or rare). When observed, ribs are relatively far apart and spread evenly over the surface of the flake scar (outside the bulb). The scar's distal edge is usually straight, and terminates in a step.

C) Georgetown flint experimental collection

(see Table I-5)

The morphological characteristics created by different types of behaviours and described in Understanding Stone Tools: A Cognitive Approach (Young and Bonnichsen, 1984) are based on the study of experimental tools made from Georgetown flint. The following summary of finds from this experimental collection is based on the book (p. 101-103, 114-117), and on personal communications with one of the authors, David E. Young.

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The relationship between platform collapse and proximal edge damage discussed above is seen on the Georgetown flint artifacts as well. Pressure, which causes more platform collapse (proximal edge is either a flat curve or a U-shaped notch), also creates flakes that exhibit somewhat less edge damage. Edge damage is rare to moderate in pressure thinning, and moderate to very extensive in pressure shaping. Percussion thinning with the billet results in extensive frequencies of edge damage, as does moderate percussion shape with the cobble. Minimal percussion thin with the cobble yields moderate frequencies of proximal margin damage. Platform collapse is somewhat less in percussion than in pressure flakes, the former exhibiting proximal edges that are mostly flat curves.

The characteristics of the bulb of force link the pressure and percussion with billet behaviours together. On flake scars created by either of these behaviours, the bulb is characteristically distinct, deep, and seen more frequently than on flakes removed with the use of the cobble. The climb from the bulb area to the remaining portion of the flake scar is rather abrupt. It is much more gradual on cobble percussion flake scars, on which the bulb is generally shallower. The shape of the bulb varies somewhat between pressure flakes and those removed by percussion with the billet. The proximal end of the bulb is narrower or "pinched" in pressure, and broader in percussion with the billet.

Ribs may, in some cases, be seen less often on pressure than on percussion flake scars. The difference in frequency between pressure and percussion is difficult to assess. In general, however, pressure results in indistinct ribs that are close together and evenly distributed across the entire flake scar. Pressure shaping may also yield ribs that are farther apart and located on the flake's distal half. Percussion with cobble flake scars exhibit mostly ribs that are relatively far apart and evenly distributed. The use of the billet often leaves behind one or two more distinctive ribs near the distal edge of the flake scar.

The straight and rounded distal edges appear to be the most common types found on flakes from the Georgetown flint experimental collection. On pressure flake scars used for thinning, the tendency for straight edges increases as more force is added in the removal of the flake. In percussion thinning with the billet, it is the rounded type that increases its frequency with the addition of force.

Most of the flake scar terminations were of the feathered type. The above-mentioned trend for straighter distal edges with increased force in pressure thinning is accompanied by an increase in frequency of step terminations as well. The same increase in step terminations, although to a lesser extent, is also observed in percussion thinning with the billet despite the fact that rounded distal edges become more frequent at higher force levels on flake scars created by that behaviour.

SECTION 2: BEHAVIOURS

(1) Pressure

In summary, the effect of pressure flaking on Georgetown flint produces more platform collapse and somewhat less edge damage than percussion. The edge damage is greater on shaping than on thinning flakes.

The bulbs from pressure flakes are quite similar to those resulting from percussion flaking with the billet: they are deep and quite distinct, with a steep slope towards their distal edge where it meets with the remainder of the flake scar. The pressure bulbs show a characteristic "pinching" at their proximal edge. That is to say, they can be quite narrow proximally.

The ribs are mostly indistinct, close together and evenly spaced (except for shaping flakes which often exhibit ribs that are farther apart and located on the flake's distal half).

The shape of the flake's distal edge is mostly straight or rounded and, in pressure thinning, becomes straighter as more force is applied. Consequently, the flake's termination is usually feathered, but may be more abrupt (step) at the substantial force level in pressure thinning.

(2) Percussion

Not all percussion behaviours are represented in the Georgetown flint experimental collection. In percussion with the billet, only thinning behaviours are included; while in cobble percussion, minimal thinning and moderate shaping behaviours are the only two represented. The following morphological summary of the percussion behaviours takes only those behaviours into consideration.

The extent of platform collapse seen in percussion flaking is less than that seen on pressure flakes, and edge damage is, correspondingly, more frequent.

As described in the segment on pressure, the bulb is deeper and steeper when created by billet percussion (or pressure), and shallower with a more gradual slope when created by the action of a cobble.

The ribs may be somewhat more frequent in percussion than in pressure, although the variability of rib presence in pressure makes it difficult to contrast these two types of behaviours. Billet percussion usually leaves one or two larger ribs near the distal end of the flake scar, while the cobble produces ribs that can be found across the entire flake scar and that are relatively far apart.

Straight and rounded distal edges are characteristic of both billet and cobble percussion flake scars. At minimal and moderate force levels in percussion thin with the billet, straight distal edges are the most common. The flake scars usually terminate gradually, in a feathered mannner on billet and cobble flake scars. An increase in force produces the emergence of a few step terminations in percussion thinning with the billet.

D) Reflex Metrograph analysis (see Table I-6)

The Project for the Study of Material Culture (Department of Anthropology, University of Alberta) houses a number of other experimental lithic collections which have been the subject of analyses by different parties. A recent (and ongoing) study by Ingelise Swartz involved the use of a digitizing apparatus referred to as a 'reflex metrograph.' With the use of this instrument, precise size and angle measurements can be obtained for a particular flake scar and recorded in a computer. Swartz recorded the X, Y, and Z coordinates that permitted her to calculate, for instance, the length of the bulb of force; its width and depth; the height of ribs and distance between them; the slope of the termination; and much more. This recording was carried out for fourteen 'substantial percussion thin with billet' flakes, six 'moderate percussion thin with billet' flakes, seven 'substantial percussion thin with hammerstone' flakes, and seven 'substantial pressure thin' flakes from experimental artifacts made of five to seven different materials (seven for 'substantial percussion thin with billet', five for all other behaviours). These materials were:

K: Knife River flint
G: Georgetown flint
M: Mt. Kineo felsite
MB: Munsungun Black (chert)
MR: Munsungun Red (chert)
N: Norway Bluff
S: Spanish Diggings quartzite

Since artifacts made up of a number of different raw materials were analysed (whereas each of the other experimental collections consist of a single raw material), the data from this group of tools does not constitute a homogeneous experimental collection. Differences in raw materials may yield different results for certain attributes from one experimental tool to the next. For that reason, only data that corroborate general trends seen among the other three collections can be used here.

The raw data from this analysis were provided by Swartz. The following sections summarize some of the results of the analysis of Swartz' data as well as some information extracted directly from the experimental artifacts by myself. Swartz' research so far is limited almost exclusively to substantial behaviours.

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Most of the percussion flakes removed with the help of the cobble exhibit some edge damage. Although most of the flake scars removed by the pressure technique also exhibit edge damage, the extent of damage is less extensive than on 'percussion with cobble' flake scars (i.e. only a slight amount of damage on each pressure flake).

Platform collapse follows the opposite pattern, with pressure causing more platform collapse than percusssion with the cobble (morphology of proximal edge: pressure: most of the flake scars exhibit a deep flat curve or a U-shaped notch; percussion with cobble: most of the flake scars exhibit a flat curve). Most percussion with billet flake scars exhibit either flat curves of deep flat curves (i.e. flat curve to U-shaped notch) at their proximal edge.

Most of the bulbs on the analysed flake scars were either distinct or at least locatable (intermediate). The length of the bulb of force is mostly moderate or substantial on pressure as well as percussion flake scars. The depth of the bulb is also quite similar from one behaviour to the next.

Most of the percussion flake scars yield ribs (N.B.: all of the percussion with cobble flake scars do so). The pressure behaviours show too much variation to be included here. The ribs are quite pronounced on most billet percussion flake scars (mostly moderate or pronounced), and less distinct on all pressure flake scars (indistinct or moderate). The distinctiveness of ribs created by billet percussion is too variable from one raw material to the other to comment on.

The spacing and location of ribs also shows much variation from one material to the next. Most of the percussion with billet flake scars, however, exhibit ribs that are far apart and evenly distributed, as well as a few that are also relatively far apart but on the distal half of the scar.

The shape of the distal edge of flake scars was also quite variable. Very few straight distal edges appear on percussion flake scars, however, and very few rounded edges appear on pressure flake scars.

Regarding flake scar termination, only the pressure scars show some consistency: most pressure scars end abruptly (step termination).

SECTION 2: BEHAVIOURS

(1) Pressure

The pressure flake scars from the artifacts analysed with the Reflex Metrograph exhibit slightly less edge damage than the percussion with cobble flake scars, and more platform collapse. Ribs seen on pressure flake scars are generally not quite as pronounced as the ribs seen on percussion flake scars (either indistinct or, at most, moderate). On most flakes, the ribs are found to be relatively far apart. Very few distal edges were found to be rounded. Accordingly, most flake scars terminate abruptly, in a step.

(2) Percussion

Most of the percussion behaviours using the cobble result in less platform collapse (flat curves vs deep flat curves and U-shaped notches in pressure) and somewhat more edge damage than observed on the pressure flakes. Percussion flaking creates ribs more often than pressure flaking; and these ribs, in billet percussion, are generally more pronounced than those seen on the pressure flake scars. The ribs seen on flake scars produced by billet percussion are relatively far apart and evenly spaced across most flake scars. The shape of the flake's distal edge is rarely straight.

E) General summary (see Table 2)

Before amalgamating the morphological information obtained from the four sources mentioned above, some comments regarding discrepancies in results are in order.

The Knife River flint collection, Lake Abitibi welded tuff collection, Georgetown flint collection, and Reflex Metrograph artifacts were analysed by four different individuals. As a result, some discrepancies are bound to arise. Despite standardization of the analytical criteria, judgement calls often have to be made.

The reflex metrograph analysis also produces results that would probably be slightly different had the analysis been done otherwise. A steep yet feathered flake termination, for example, would probably be called 'step' on the basis of the difference in elevation between the two points recorded, one being located just ahead of, and the other just behind the distal edge of the flake scar.

According to Swartz (personal communication), the measurements of bulb length, using the reflex metrograph, were arbitrary in the cases where the exact position of the bulb's termination point was difficult to ascertain. In the other three collections, the statistics for bulb length were drawn from measurements of distinct and intermediate bulbs only. This difference, again, may cause some discrepancies

TABLE 2: GENERAL DATA SUMMARY (ALL COLLECTIONS)

Attributes	Knife River flint	Lake Abitibi welded tuff	Georgetown flint	Reflex Metrograph
Edge Damage	- → + PR C B	- → + PR B/C	- → + PR C B	- → + PR C
Platf. Coll.	- → + B C PR	- → + B/C PR	- → + B/C PR	- → + B C PR
Bulb Distinct	- → + PR B C	- → + C/B/PR	- → + C B/PR	**
Bulb Length	- → + PR B/C	**	- → + PR B	**
Bulb Depth	**	**	- → + C B/PR	**
Ribs: Presence	- → + B PR C	- → + PR C B	- → + PR B C	- → + B C
Ribs: Distinct	- → + PR B C	- → + PR/C/B	- → + PR/C/B	- → + PR B
Ribs Spacing	PR: CL & E/ CL & D$\frac{1}{2}$* B: CL & D$\frac{1}{2}$ C: CL & E	PR: CL & E B: F & D$\frac{1}{2}$ (often 2 pron. ribs near termination) C: F & E	PR: CL & E (shaping: often F & D$\frac{1}{2}$) B: CL & E or Var. (often 2 pron. near termination) C: F & E	PR: mostly FAR apart B: mostly F & E
Distal Shape	PR: 50% IRR. 31% STR. 19% RD. B: 46% RD. 41% IRR. 13% STR. C: 49% IRR. 41% RD. 10% STR.	PR: mostly RD some STR & IRR B: RD & STR C: STR	PR: STR or RD B: STR (or STR & RD at subst. force) C: STR & RD	PR: very few RD B: very few STR C: very few STR
Termination	PR: 61% FEATH B: 58% FEATH 42% STEP C: 71 % FEATH	PR: more FEATH than STEP B: FEATH & STEP C: STEP	PR: FEATH. B: FEATH. C: FEATH.	PR: mostly STEP (71%)

* See Table 1 regarding abbreviated terms

** Data insufficient or inconclusive

between the Reflex Metrograph artifacts bulb size data, and the same data drawn from the other collections of experimental artifacts.

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(1) Edge damage and platform collapse

In all three main collections, (Knife River flint, Lake Abitibi welded tuff, and Georgetown flint) the pressure flakes show a greater degree of platform collapse and a lower incidence of edge damage than the percussion flakes. With the exception of billet percussion, most experimental tools analysed with the Reflex Metrograph appear to fit this pattern. Within the percussion group, the inverse relationship between edge damage and platform collapse is not apparent in the Reflex Metrograph, Lake Abitibi, and Georgetown flint collections. It is, however, in the Knife River flint collection.

Knife River flint:	edge damage	– ⟶ + [PR] [C] [B]	inverse
	platform collapse	+ ⟵ – [PR] [C] [B]	relationship
Reflex Metrograph:	edge damage	– ⟶ + [PR] [C]	inverse relationship (percussion vs pressure only)
	platform collapse	+ ⟵ – [PR] [C B]	

Lake Abitibi:	edge damage	$- \longrightarrow +$ [PR] [B/C]	inverse relationship (percussion vs pressure only)
	platform collapse	$+ \longleftarrow -$ [PR] [B/C]	
Georgetown flint:	edge damage	$- \longrightarrow +$ [PR] [C B]	inverse relationship (percussion vs pressure only)
	platform collapse	$+ \longleftarrow -$ [B/C] [PR]	

(2) Bulb of percussion or bulb of force

The bulb of force was found to be mostly indistinct in pressure flaking in the Knife River flint collection (although visible bulbs are found on 46% of flake scars: also a high percentage) and in the Lake Abitibi collection, but quite distinct in the Georgetown flint collection.

There is some contrast between the collections regarding bulb presence on percussion flake scars as well. The Knife River flint collection yields 58% visible bulbs and 42% not visible. The Lake Abitibi collection rarely exhibits bulbs. In the Georgetown flint collection, bulbs are seen more frequently on flake scars created by the billet than on those resulting from cobble percussion.

The length of the bulb is similar from one behaviour to the next in the four collections. The only exception is for flakes removed by the billet in the Lake Abitibi collection. These appear to be somewhat longer than the bulbs resulting from other types of behaviours.

The depth of the bulb appears relevant in the Georgetown flint and Lake Abitibi collections (it was not assessed in the Knife River flint collection). In the former two collections, billet work usually results in deeper bulbs of force. In the Georgetown flint collection, pressure flaking also results in deep bulbs.

(3) Ribs

The presence or absence of ribs on flake scars does not present a generally uniform pattern across all four sets of data. The results for the pressure behaviours are quite different from one collection to the next, although pressure flaking consistently shows ribs less often than does percussion with the cobble. The presence/absence of ribs associated with billet percussion behaviour units also varies, although to a lesser extent. This may be one case where the analyst's perception of morphological detail culminates in widely different results. On the other hand, the welded tuff experimental artifacts (Lake Abitibi collection) consistently show ribs less often than the artifacts from the other three collections. The coarseness of the welded tuff surely accounts for that as it obscures detail.

The distinctiveness of the ribs appears to cause fewer problems than their prevalence. The analysis of the Lake Abitibi, Georgetown flint, and Knife River flint collections lead the investigators to conclude the majority of ribs were faint (Knife River flint: 52% indistinct ribs).

The spacing of the ribs, like the frequency of their presence, also appears to be affected by the analyst's perception of morphological features. In the Knife River flint collection, the great majority (approximately 87%) of ribbed flake scars display ribs that are close together. The Lake Abitibi and Georgetown flint collections exhibit ribs that are closer together on the pressure flakes, and farther apart on the percussion flakes.

Regarding the location of these ribs, one observation is obvious in the Georgetown flint, Knife River flint, and Lake Abitibi collections: percussion with the billet generates more distally located ribs (i.e. on distal half only) than any other behaviour. In the Lake Abitibi and Georgetown flint collections, cobble percussion and pressure yield mostly flakes that are evenly distributed. In the Knife River flint collection, ribs located on the distal half are found on 90% of the billet flakes, 43% of the pressure flakes, and 24% of the percussion with cobble flake scars.

(4) Distal shape

The Knife River flint collection yields many more irrregular distal edges than the other collections. This may be due to one of three reasons:

1- The coat of paint applied to the Knife River flint experimental artifacts for contrast, prior to flake removal, was too thick and the contact zone it created, as well as the greater elasticity of this new substance, may have produced many more irregular distal edges than would otherwise have been created had the paint not been used (see Appendix II, B) Section 2, Subsection 3 (4) b).

2- The decisiveness with which the shape of the distal edge was assessed may have been less absolute in the case of the Knife River flint collection. That is to say, a distal edge with a rough approximation of a rounded edge may have been called simply 'rounded' by Pollock or Young (respectively, Lake Abitibi collection analyst, and Georgetown flint collection analyst), but 'rounded to irregular' by me (Knife River flint collection analyst).

3- The third possibility is simple: Knife River flint may flake in a way that results in an irregular distal edge more often than in other lithic raw materials.

Of course, all three possibilities may have affected the outcome of the analysis of the flakes' distal edge.

No general comments can be made about the relationship between flaking behaviour and resulting shape of the distal edge of the flake scar because all the collections yield different results (see Table 2). The pressure techniques result in more irregular distal edges in the Knife River flint collection, more rounded edges in the Lake Abitibi collection, and in straight and rounded edges in the Georgetown flint collection. The percussion with billet techniques produce similar percentages of rounded and irregular distal edges and few straight edges (13%) in the Knife River flint collection; and mostly rounded and straight edges in the Lake Abitibi and Georgetown flint collections.

The percussion techniques making use of the cobble produce more irregular and rounded than straight edges in the Knife River flint collection. In the Lake Abitibi collection, however, the straight distal edge is most common; while in the Georgetown flint collection, straight and round distal edges are seen equally often. In the Knife River flint collection, irregular edges are slightly more common than the rounded type (49% for irregular vs 41% for rounded).

(5) Termination

In all three collections (Reflex Metrograph data not included), gradual flake scar terminations (i.e. feathered) were more common than the abrupt step type. Very few generalizations can be made across the three collections. Feathered terminations are more common than step when using pressure in the all three collections. Feathered terminations are also preponderant on percussion flake scars in the Knife River flint and Georgetown flint collections, but not in the Lake Abitibi collection (Lake Abitibi: percussion with billet: equal ratio of feathered and step terminations; percussion with cobble: mostly step terminations). Step terminations begin to appear as force is increased in percussion with billet and pressure in the Georgetown flint collection.

SECTION 2: BEHAVIOURS

(1) Pressure

The evidence from all experimental collections (Reflex Metrograph data included) shows that pressure flaking results in more platform collapse and in less edge damage then the percussion techniques. This confirms the observation made on the Knife River flint collection, that the more extensive the platform collapse, the less the remaining edge damage. Pressure flaking results in proximal edges shaped as flat curves or U-shaped notches in 70 to 100% of cases.

No all-encompassing trends regarding pressure flaking and the presence/absence of the bulb could be observed. Bulbs of force were visible -2- on only 46% of flake scars in the Knife River flint collection, while they were quite frequent in the Georgetown flint collection.

Ribs are not seen quite as often on pressure flakes as on flakes removed by percussion. There is, however, one exception: in the Knife River flint collection, percussion with the billet produces ribs less often than pressure. The actual frequency with which ribs are seen on pressure flakes is much less for the Lake Abitibi welded tuff collection than for the other collections. This result was explained earlier by the fact the roughness of the welded tuff (larger grain size) hides some of the detail.

Pressure flaking not only produces ribs less often than percussion but it also produces ribs that are less prominent than those seen on percussion flake scars (except for the welded tuff collection,in which all pressure and percussion behaviours produce ribs that are indistinct. The evidence from the Reflex Metrograph analysis appears to corroborate this information. In fact, the majority of ribs resulting from a pressure behaviour were coded as 'indistinct'.

The ribs were found to be, for the most part, evenly distributed across the entire flake scar (Lake Abitibi, and Georgetown flint collections); or an even mixture of 'evenly distributed' and of 'located on the distal half of the flake scar' (Knife River flint collection). They were also found to be closely spaced in the Lake Abitibi, Georgetown flint, and Knife River flint collections.

Most of the pressure flake scars ended in a gentle slope (feathered termination) in the Knife River flint, Georgetown flint, and Lake Abitibi collections.

(2) Percussion

Percussion flaking in general produces less platform collapse than pressure and, as a result, leaves a greater portion of the damaged platform to be observed.

The evidence from the three main collections was not, however, in agreement regarding which of the billet or cobble results in more platform collapse and less visible edge damage than the other. In the Knife River flint collection, percussion with the billet results in slightly less platform collapse than percussion with the cobble. The edge damage is correspondingly more frequent in billet than in cobble percussion. The Lake Abitibi experimental artifacts show equal frequencies of edge damage and equal amounts of platform collapse for the flake scars created by percussion with the cobble and those created with the help of the billet. The Georgetown flint collection yielded a similar extent of platform collapse for the billet and cobble flakes, but somewhat more edge damage for the billet than for the percussion behaviours.

Again, as was the case for pressure flake scars, no general links could be found between percussion flaking and the frequency of presence or absence of a bulb of force. Yet the Knife River flint collection showed visible bulbs on at least 67% of the percussion with cobble flake scars, while the Lake Abitibi collection revealed very few visible bulbs on the same type of flake scars. The size of the welded tuff grain may account for this result since the bulb is not generally visible on the flake scars from artifacts made from that raw material. The actual frequency of bulb presence for the Georgetown flint experiments was not available, although billet and pressure bulbs are more distinct, and may, therefore, be seen more frequently.

On most occasions, ribs are present somewhat more frequently on percussion than on pressure flake scars. The use of the cobble results in greater frequencies of ribs than the use of the billet in three of the four collections (Knife River flint and Georgetown flint). The opposite occurred in the Lake Abitibi collection.

Except in the Lake Abitibi collection where all ribs, regardless of technique, are 'indistinct,' percussion flaking usually produces ribs that are more prominent than those resulting from a pressure behaviour.

A tendency was observed for ribs that were evenly distributed across the entire flake scar (and either closely spaced or farther apart). The billet, on the other hand, left ribs mostly located on the distal half of the flake scar in the Knife River flint, Georgetown flint, and Lake Abitibi collections. The ribs resulting from billet percussion were far apart in the Lake Abitibi collection, and close together in the Knife River flint and Georgetown flint collections.

Rounded distal flake edges may be found somewhat more frequently on percussion flakes than on their pressure counterparts.

As for the flake scar termination, no global differences were found between pressure and percussion techniques. In the Lake Abitibi collection, the step termination is either as frequent as, or more frequent than, the feathered type in percussion flake scars, while the feathered terminations predominate in pressure. In the Knife River flint and Georgetown flint collections, both the pressure and percussion techniques most often result in feathered flake scar terminations.

Chapter III. FORCE WAVES

A) Theory

(1) Introduction

The behaviour of force waves travelling through a solid has been studied by physicists and engineers. Most studies, however, consider very simple and ideal conditions. From these, certain principles can be extracted. But only the most basic of these principles can be applied to flintknapping studies since the shape of the worked artifact, the irregularity of its surface, the lack of homogeneity of the raw material within a single artifact, and the cracks or flaws already present within that artifact render the situation much more complex than that seen in the physicist's or engineer's model. The reality of a stone tool includes so many different variables that the exact behaviour of the force waves transmitted to the artifact by the flaking tool could not be accurately described or predicted even with computer simulation. To my knowledge, no such study has yet been undertaken. The reason is probably lack of comprehension: because of the level of complexity involved, the archaeologists/anthropologists do not understand the force wave theories, and the physicists/engineers are seldom interested in applying the force wave theories to archaeological artifacts. The ideal type of researcher would be one with a degree in physics or engineering and a second degree in anthropology (or archaeology).

The following information on the behaviour of force waves in solids was drawn from Kolsky and Rader (1968), Gash (1971), Rinehart, (1960), Lawn and Wilshaw (1975), McClintock and Argon (1966), Rinehart and Pearson (1954), and Bonnichsen (1977). To my knowledge, Bonnichsen is, until now, the only archaeologist who has tried to reconcile force wave behaviour theories with flintknapping. Enlightening conversations with Franz Vitovec of the Mechanical Engineering department, and with Michael Wayman of the Mineral Engineering department, both at the University of Alberta, provided me with even more information and helped me make sense of what I read.

(2) Theories regarding the behaviour of force waves

Regardless of the method used in removing a flake, the force waves sent through the worked artifact by the action of the flaking tool are reflected back into the artifact after hitting a free surface (see Fig. 6). The far edge of the rock acts like a reflector thus reflecting the incoming wave, referred to as the compression wave, back into the body of the rock. The reflected wave becomes a tension wave. As a result, regions of high stress are created within the rock. Stress can be defined as the amount of "force per unit area"

(McClintock and Argon, 1966).

Figure 6 represents force waves travelling through a solid whose shape and surface lines are regular, and composition (raw material) homogeneous. Stone preforms have uneven surfaces and may contain other imbedded materials, minute cracks or flaws, and different grain sizes. Moreover, their shape dictates that not all incoming force waves will encounter a free surface at the same time and, thus, will not be reflected at the same time (see Fig. 7). This means that high stress caused by the meeting of incoming compression waves and reflected tension waves (Rinehart, ed., 1960: 87) will occur at different times in different areas. Figure 8 presents a much simplified version of this phenomenon. Three incoming force waves are represented as A, B, and C. Two of these, A and B, have reached a free surface and have been reflected (as A' and B') in the time it took wave C to reach a free surface. Two later incoming waves, D and E, meet respectively reflected waves A' and B', thus causing a zone of high stress where they meet.

As stated by Rinehart and Pearson (1954:146-147), Bonnichsen (1977:93-94), and Vitovec (personal communication, 1985), there are very important differences between static loading and impulse or dynamic loading. In static loading, the force is applied to the solid over a relatively long period of time (Bonnichsen, 1977:93). This is the type of loading that would be typical of the pressure flaking behaviours. In dynamic loading, the force is rapidly transmitted to the surface of the material (Idem). This situation would apply to the percussion behaviours.

According to Vitovec (personal communication, 1985), in pressure flaking (static loading) the pressure itself pushes layers of the stone, thus generating a crack. As the crack begins to propagate, it generates waves which are reflected and create high stress regions which, in turn, influence the crack. In other words, pushing on the rock creates the initial crack, but the stress waves do not appear until after the crack has been initiated.

In percussion flaking (dynamic loading), on the other hand, the blow to the artifact generates stress waves which, in turn, generate a crack. The advance of the crack is influenced by further stress waves. Whereas in pressure flaking the initial fracture precedes stress waves, in percussion flaking, stress waves precede and cause the initial fracture (Idem).

Because of this important difference between static and impulse or dynamic loading, there are also differences between pressure and percussion flaking, in the propagation speed of the fracture. In pressure flaking (static loading), the crack propagates faster at first because it is unimpaired. In percussion flaking (dynamic loading), it is believed the velocity of the crack is lower at first, and increases as the fracture progresses (Idem).

Another important variable lies in the fact that, in pressure flaking, less force is generally needed to promote fracture. This is likely due to the fact that, in pressure flaking or static loading, the force is applied over a longer period of time than in percussion flaking or dynamic loading. It has been shown that:

> When glass is subjected to a constant stress somewhat below the average expected fracture stress value obtained in rapid loading (10^{-5} sec^{-1}), fracture will nevertheless occur after a certain period of delay which depends on the stress margin. Thus, for instance, Holland and Turner (1940) have observed a reduction in strength of 70% in bent glass plates when the time was increased from 34 seconds to 34 hours. (McClintock and Argon, 1966: 499)

This phenomenon, known as 'static fatigue,' gradually lowers the strength of the material. The result is that pressure flaking requires less strength than percussion to remove a flake. If less force is sent through the material, the intensity or amplitude of the incoming and reflected force waves will be lesser (see Fig. 9), thus causing less stress within the material (Wayman, personal communication, 1985).

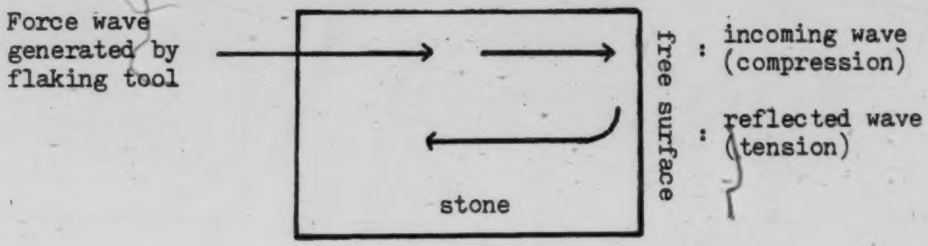

Force wave generated by flaking tool
free surface
: incoming wave (compression)
: reflected wave (tension)
stone

Figure 6. Compression and Tension Force Waves (after Rinehart and Pearson, 1954)

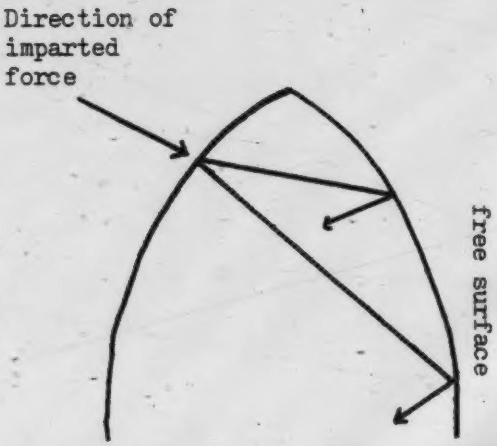

Direction of imparted force
free surface

Figure 7. Effect of Artifact Shape on Force Wave Reflection

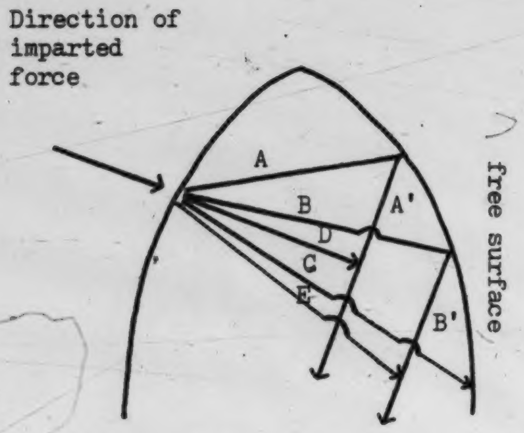

Direction of imparted force
free surface
A
B
D
C
E
A'
B'

Figure 8. Effect of Artifact Shape on Location of High Stress Zones

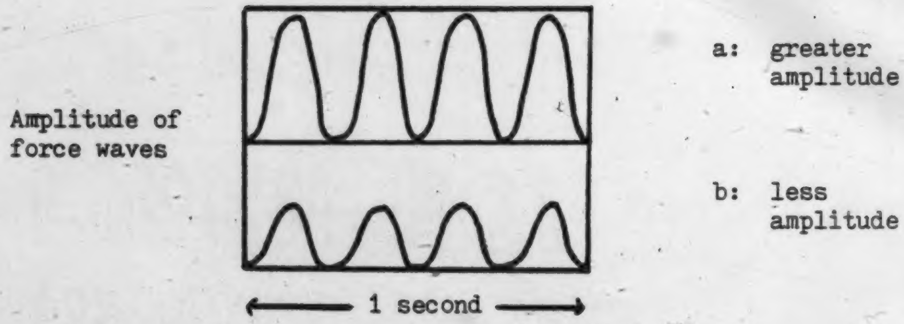

Amplitude of force waves
a: greater amplitude
b: less amplitude
1 second

Figure 9. Amplitude of Force Waves

B) Application of force wave theories to morphological data

The following section will attempt to explain some of the morphological finds (previously outlined) that emerged from the study of the Knife River flint, Lake Abitibi, Georgetown flint, and Reflex Metrograph collections. The section will be divided into discussions of specific morphological traits. The discussion relating to each trait will begin with a consideration of what one might expect to find in view of specific aspects of force wave behaviour. This will be followed by a discussion of how the observed morphological characteristics relate to our theoretical expectations.

(1) Bulb of force

Since, as stated above, the greatest amount of force is encountered at the beginning of the crack in pressure flaking, and since, in percussion flaking, the force is weakest at the start and gradually builds up, one might expect to find more frequent and deeper bulbs of force in pressure flaking than in percussion flaking. This result would be explained by the fact that greater initial force in pressure flaking should remove more material from the proximal section of the flake scar.

Unfortunately, bulb depth measurements were not taken for the Knife River flint collection. In the Lake Abitibi collection, the billet percussion behaviours appear to create the deepest bulbs of force. In the Georgetown flint collection, both pressure and billet percussion create the deepest bulbs.

As for the frequency with which bulbs of force are seen as the result of a particular flaking behaviour, neither of the four experimental collections has shown that pressure flaking produces visible bulbs of force more often than both cobble and billet percussion. In this case the facts do not appear to fit the theory. Yet there is a related variable one should consider here. The more extensive loss of platform area in pressure than in percussion flaking might remove most traces of a bulb of force. This possibility should at least be considered even though the Georgetown flint data do not appear to agree.

(2) Length and depth of the flake scar -8-

It is believed that dynamic loading (i.e. percussion) provokes a crack that is slower at first but whose speed builds up as the crack advances. With greater and greater crack speed, more and higher intensity stress waves are believed to be produced. This means percussion should ultimately remove more material than pressure, resulting in a longer, thicker flake in percussion as compared to pressure at the same perceived force level.

Data for flake thickness, beyond the bulb of force, was obtained for the Reflex Metrograph collection only, but was not included in this study.

As for flake scar length, both the Knife River flint and Reflex Metrograph collections (data was not obtained from the Lake Abitibi nor from the Georgetown flint collections for the purpose of this study) seem to indicate that at the same perceived force level, and within the shaping as well as within the thinning groups of behaviours, pressure quite often results in flake scars that are shorter than the percussion flake scars (see Table 3). In other words, the observed pattern appears to fit the theory.

TABLE 3: FLAKE SCAR LENGTH (KNIFE RIVER FLINT AND REFLEX METROGRAPH EXPERIMENTAL COLLECTIONS)

		THINNING									SHAPING					
		MINIMAL			MODERATE			SUBSTANTIAL			MINIMAL			MODERATE		
KNIFE RIVER FLINT:		PRESS	BILL	COBB	PRESS	BILL	COBB	PRESS	BILL	COBB	PRESS	BILL	COBB	PRESS	BILL	COBB.
RELATIVE LENGTH	VERY MINIMAL	78%	25%	43%		30%	33%	8%			92%	90%	100%	78%	60%	33%
	MINIMAL	22%	75%	43%	50%	36%	11%	53%			8%	10%		22%	33%	56%
	MODERATE			16%	50%	30%	33%	36%	25%						8%	11%
	SUBSTANTIAL					5%		11%	25%	33%						
	VERY SUBSTANTIAL					5%	22%		50%	67%						

REFLEX METROGRAPH:*

RANGE (mm.):		9 to 16	10 to 57	25 to 42
AVERAGE (mm.):		12.3	33.4	30
MEDIAN (mm.):		12	33	29

* Data for substantial thinning behaviours only

(3) Ribs

a) presence and distinctiveness

Since pressure flaking (static loading) generates less force than percussion, it generates reflected waves of lesser intensity (or amplitude) and thus their interference (meeting) generates lower stresses. Moreover, according to Vitovec (personal communication, 1985), ribs are a direct result of the intensity of the stress waves.

From these two pieces of information, one would expect to find ribs less often on pressure than on percussion flake scars and, when present, the distinctiveness of these ribs should be lesser on the pressure flake scars than on the percussion scars.

The predictions are correct: pressure consistently yields lower frequencies of ribs, and the majority of these are 'indistinct.' The ribs from percussion flake scars are generally more prominent.

b) location

We have already noted that ribs result from the interference of stress waves. As discussed above, in percussion flaking the speed of the fracture is continuously accelerating, creating more and more force waves. The amplitude of the stress waves, therefore, could be increasing from the proximal to the distal end of a propagating crack resulting from a percussion behaviour. This implies that, in percussion, ribs should become more and more distinct as they progress from the flake scar's proximal margin to its distal edge. Thus the ribs may: 1- either be visible only on the distal half of the flake scar or; 2- if visible on the entire flake scar, may be evenly spaced across the entire flake scar (outside the bulb of force), but more prominent near the distal end than near the proximal end (i.e. just outside the bulb).

The morphological evidence, however, does not completely corroborate this supposition. Billet percussion does produce ribs more often (or ribs that are more prominent) on the distal half of the flake scar in the Knife River flint, Georgetown flint, and Lake Abitibi collections. Cobble percussion results mostly in ribs that are evenly distributed across the entire flake scar.

Pollock (1984: 187) and Young and Bonnichsen (1984: 102) did notice, in their studies of the Lake Abitibi and Georgetown flint experimental collections, that flake scars created by billet percussion often exhibit one or two distinct ridges near the scar's termination. This may be a direct result of the increased intensity of stress waves towards the distal edge of the flake scar.

(4) Termination

Section (2) on the length and depth of the flake scar predicted a longer and thicker flake when percussion is used. We saw that percussion flakes are, in fact, longer than pressure flakes; the thickness assumption, however, was not tested.

If we assume percussion flakes are indeed thicker than pressure flakes, we might predict more step terminations for the percussion flake scars than for their pressure counterparts. Yet, this is not generally the case: step terminations are more common than feathered terminations in the cobble percussion samples from the Lake Abitibi experimental collection only. In all other cases, feathered terminations are either equal to in frequency or predominate over step terminations in percussion flakes. Feathered terminations also predominate among pressure flake scars. It may very well be that the type of termination of a flake s car has little to do with the force wave amplitude, and, therefore, with the flaking method used.

(5) Flake scar shape

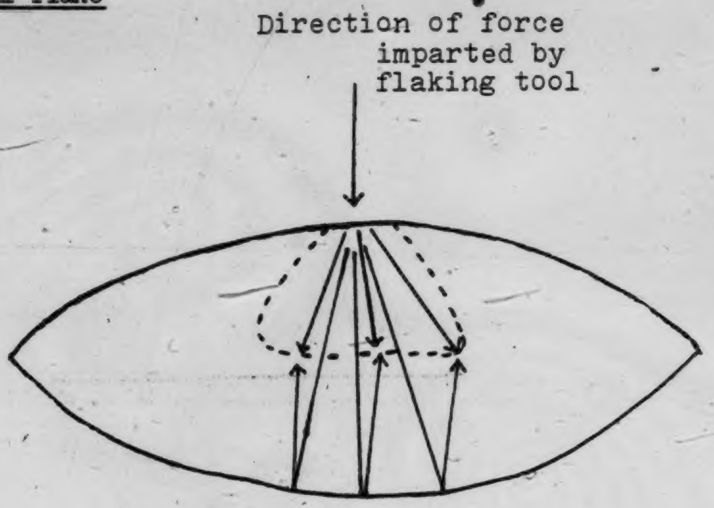
As we have seen earlier, the fact the sides of a preform are not, along most of its perimeter, perpendicular to each other means that certain waves will take longer to reach a free surface, be reflected, and create stress. With this in mind we may be able to roughly predict the shape of a flake.

In a flake struck midway down the side of a fairly symmetrical preform (see Fig. 10a), at a point where both sides of the preform are roughly parallel, the incoming force waves released at the same time should take approximately the same time to reach the other side, return, and create stress as they meet new incoming waves. This, of course, assumes the raw material is relatively homogeneous in its composition and internal flaw distribution. Such a flake should, therefore, be fairly regular in shape (see Fig. 10a).

Had the flake been struck from another location, say near the tip of the preform, the situation would have been different (see Fig. 10b). The force waves travelling toward the tip of the preform (e.g. wave A in Fig. 10b) meet a free surface, are reflected, and meet new incoming waves, causing stress, much sooner than the waves travelling toward the centre of the artifact (e.g. wave B in Fig. 10b). The result, ideally conceived, should be a lopsided flake with its shorter side toward the tip and its longer side toward the centre of the preform (see Fig. 10b).

A very quick survey of some of the experimental tools from the Project for the Study of Material Culture laboratory (Department of Anthropology, University of Alberta) hinted that this prediction might prove to be correct. But the survey was neither systematic nor extensive enough to warrant conclusions.

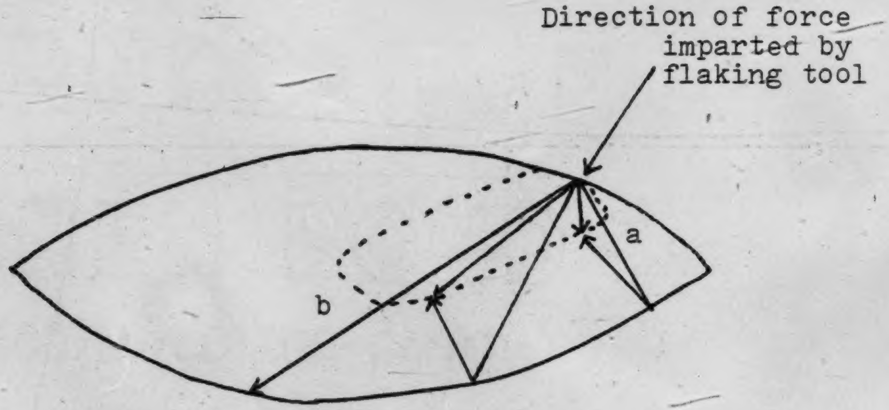
a) Regular flake



Direction of force imparted by flaking tool

(highly simplified situation)

b) Asymmetrical flake



Direction of force imparted by flaking tool

(highly simplified situation)

Figure 10. Effect of Force Waves on Flake Scar Shape

Chapter IV. SUMMARY AND CONCLUSIONS

A) The morphology of flintknapping

The purpose of this study was to document further the process of flake removal through the analysis of the Knife River flint experimental collection, and by comparing that data set to other experimental collections, in order to formulate a set of rules or observations regarding the relationship between certain behaviours and the morphological characteristics they produce on stone.

The first part of this conclusion will summarize the most important finds from the analysis of the Knife River flint collection. The second section will look at the results of the comparisons among the four experimental collections, and the third section will link these findings with theories regarding the behaviour of force waves in solids.

(1) Knife River flint experimental collection

a) behaviours

The analysis of flake scars belonging to the 'edge unit' group of behaviours (shearing and rub behaviours) has revealed very few bulbs. When bulbs are observed, are proportionally quite small (i.e. when compared to total length of flake scar). Edge units appear to produce ribs less often than pressure or percussion. Also, these ribs are distinctive slightly more often than in pressure flaking, but much less often than in percussion. They are generally 'indistinct' 60% of the time. Using an edge unit results in some proximal margin damage more often than when using pressure but less so than when using percussion. Very little platform collapse can be seen on the tiny edge unit flake scars. These flake scars usually terminate gradually (62% feathered); and their distal edge can be either rounded (44% of cases), straight (30%), or irregular (26%). The different edge unit behaviours result in morphological characteristics that are rather similar to each other. The small size of the flakes also makes it difficult to assess the state of certain morphological traits without a doubt. The latter two facts distinguish edge unit flake scars from other types of flake scars on one hand, and on the other hand, make it more difficult to distinguish among the different edge units. 'Edge press on anvil' shares many of the morphological characteristics that generally result from the use of an edge unit behaviour and, as a result, should be classed as an edge unit. As a group, the edge units are closer, morphologically and technologically, to the pressure behaviours than to the percussion behaviours.

Since pressure and percussion behaviours are most often contrasted with each other, they can best be summarized together. Pressure flaking results in more platform collapse and less frequent edge damage than percussion. Thus, percussion flake scars exhibit edge damage more often because more of the damaged platform area remains but also because, in percussion flaking, more attempts are required to remove flakes than in pressure flaking. The more often the flintknapper hits the edge of a preform without success, the more edge damage is likely to occur. Ribs appear to be produced most often on percussion flake scars used for thinning the artifact, and less often on flakes removed by pressure or on flakes intended to shape the artifact. Ribs produced by a percussion technique are generally more prominent than those seen on pressure flake scars. The likelihood of seeing a bulb of force is somewhat greater on the percussion flake scars, although the size of bulbs found on percussion and pressure flakes is much the same.

Billet percussion seems to result in more edge damage, slightly less platform collapse, lower frequency and distinctiveness of ribs, and slightly fewer bulbs than percussion with the cobble. The ribs seen on billet percussion flakes are also located on the distal half of the flake scar in 90% of instances; while on flakes removed by cobble percussion, the ribs may be either evenly distributed or located on the distal half.

The pressure and percussion behaviour groups are legitimate groupings of behaviours, as are the edge units, since the behaviours that make up each group correlate morphologically, as a group, more closely to each other than to other groups. The pressure behaviours, for instance, have more in common morphologically with each other than they have with percussion or edge unit behaviours. This, however, does not preclude links between certain behaviours from different groups. As a group, the pressure behaviours are slightly closer to the edge unit gr oup than they are to the percussion group; and the percussion group is somewhat closer to the pressure group than to the edge unit group.

The thinning units require platform preparation, to thicken the edge and remove projections, more often than do the shaping units. This procedure is followed in order to gain better control over the shape and size of the thinning flakes and to prevent collapse of the platform area. Ribs are seen more often on thinninn flake scars than on shaping scars. The thinning behaviours create the illusion of more platform collapse than the shaping behaviours. Yet we know that, in fact, the shaping behaviours are intended to create more platform collapse in order to move in the preform's margin by overlapping a series of platform-collapsing shaping flakes. The overlapping, not necessarily seen in thinning flakes, removes the sides of the previous flake's proximal edge, thus flattening out that edge and giving the impression of less platform collapse (straighter proximal edges) than in thinning.

The substantial thinning behaviours are the easiest to identify since they produce few morphological characteristics that are shared with other types of behaviours.

b) attributes

In the Knife River flint collection, edge damage was seen more often on the percussion flake scars than on the pressure scars. The edge units fell somewhere in between. Platform collapse was, accordingly, more extensive in the pressure than in the percussion units. The edge units exhibited the least amount of platform collapse. The thinning units also yielded more apparent platform collapse than the shaping units. This result was explained by the fact that flake overlapping flattens out the individual flakes' proximal edge in the shaping behaviours.

The edge damage and platform collapse morphological attributes appear to be related in the pressure and percussion behaviours: the more platform collapse is created by a behaviour, the less edge damage can be seen, the bulk of it having been removed by the collapse of the platform area.

Edge damage seems to be associated with the success rate of the behaviour: the more attempts made before a successful flake is removed (as in percussion), the more edge damage is observed on the flake scars that are eventually created.

The presence/absence of ribs is difficult to rate from one behaviour to another. ~~A~~ tentative scheme might have the edge units at the lowest end of the scale, followed by billet percussion, pressure, and, at the upper end of the scale, percussion with the cobble. The thinning behaviours create ribs more often than their shaping counterparts.

The distinctiveness of the ribs is generally greatest for the percussion behaviours and least for the pressure behaviours, with the edge units falling in between. The ribs created by thinning behaviours are not only seen more frequently, but are also more distinct than those created by shaping behaviours.

The spacing and location of the ribs varies as follows:

-percussion with billet: close together and on the distal half of the flake scar
-percussion with cobble: close together and on the distal half of the flake scar, or evenly distributed across it
-pressure: close together and evenly distributed, or located on the distal half of the scar
-edge units: close together and evenly distributed, or located on the distal half of the scar

Bulbs are generally seen more often on percussion flake scars than on pressure, and on pressure than on the edge unit flake scars. The likelihood of seeing a bulb increases with the amount of force applied to the preform, but the extent of edge damage may reduce the chances of seeing that bulb at the greater force levels. The thinning flakes yield bulbs somewhat more often than the shaping flakes.

The relative size of the bulb (relative to total flake scar length) is smallest for the edge units. Pressure and percussion all yield bulbs of a comparable size, as do the thinning and shaping units (thinning: slightly smaller bulb). As for the distal shape of the flake scars, irregular edges are most common, possibly because of the thickness of the coat of paint applied to the preform prior to flaking; but decrease in frequency with the application of increased amounts of force. Straight distal edges can be seen more often on pressure flakes, and rounded distal edges on percussion and edge unit flakes.

Most flake scars end gradually in a feathered type of termination. The step terminations are characteristic only of the pressure thinning and of the rub unit flake scars.

The flake scar's distal shape and termination type are closely associated: 60% of the straight distal edges terminate in a step fashion; 73% of the rounded distal edges and 64% of the irregular distal edges are feathered.

(2) General summary

a) attributes

This general summary will draw upon the attributes that show some consistency across all (or most) of the experimental collections described earlier. It will, therefore, point to some general observations regarding the morphological effect of certain flaking behaviours, regardless of raw material.

A definite trend was detected between the pressure and percussion behaviours regarding the extent of platform collapse and of edge damage observed on flake scars. The more the platform area has collapsed in the flaking process (e.g. pressure), the less edge damage remains to be recorded, and vice-versa.

The length of the bulb does not generally appear to be affected by the type of behaviour used to produce it. Both pressure and percussion result in bulbs of a similar size.

Ribs are usually less frequent and less distinct on pressure flakes than they are on their percussion counterparts, providing the raw material is fine enough that ribs can be seen at all on any type of flake. The coarser raw materials, such as the welded tuff from the Lake Abitibi collection, hide much of the morphological detail such as ribs and bulbs.

The feathered type of termination appears to be the most common, limiting the step type to a few behaviours and occasions only.

b) behaviours

In general, pressure flaking creates more platform collapse, less edge damage, and lower frequencies of ribs that are, for the most part, indistinct. These ribs are either mostly evenly distributed across the entire flake scar, or the artifacts show roughly equal frequencies of flakes with evenly distributed ribs and ribs located on the distal half.

Percussion yield flakes with more edge damage, less platform collapse, higher frequencies of ribs (that are also more prominent), and more rounded distal edges than the pressure behaviours. The ribs created by cobble percussion are usually evenly distributed. Those resulting from billet percussion are either seen mostly on the distal half of the scar, or are most prominent at that end of the scar.

c) force waves

The force wave theories outlined earlier appear to make some sense out of some of the morphological information associated with specific behaviours.

Static loading, the type associated with pressure flaking, results in a crack that propagates faster at first and then decreases in speed. This might account for greater bulb depth in pressure than in percussion flaking. Only the Georgetown flint data corroborate this assumption regarding bulb depth.

Static loading also requires less force than dynamic loading before similar flakes can be removed. Since ribs are the representation of the amplitude, and therefore of the level of stress caused by the interference (meeting) of the force waves, pressure flaking (static loading) is expected to, and does in fact, produce ribs less frequently and ribs of a smaller size than those seen on the percussion flakes (dynamic loading).

The gradual building up of speed in dynamic loading also suggests that ribs might be more distinct near the flake's distal end. This factor may explain why one or two larger ribs can be found near the termination in billet percussion. The building up of force in percussion seems to produce longer flakes than the pressure behaviours (data from only two of the four collections).

Although the force wave theories considered here represent highly idealized conditions, they do appear to shed some light on certain morphological characteristics produced by specific behaviours. It is left to the physicists and engineers to determine whether the links between force wave behaviour and flake scar morphology outlined in this work actually do make sense.

B) General conclusions

A major purpose of this research was to document further the process of flake formation by analyzing the morphological results of specific types of flintknapping behaviours on Knife River flint. This information was then compared to similar information obtained by other researchers from three different experimental collections.

The results show that some generalizations can be made across (raw) materials; and that broad groups of behaviours, such as pressure and percussion, can be distinguished from one another through their morphological outcome on stone. Despite numerous differences between the collections, it was found, for instance, that pressure flaking causes more platform collapse, less visible edge damage, and lower frequencies of ribs that are, for the most part, less distinct than in percussion flaking. These trends and others were obvious despite such variables as raw material, shape of artifacts, method of investigation (human observation alone vs. human observation and digitizing with Reflex Metrograph), investigator, sample size, judgement calls, different perception of certain attribute definitions (e.g. when is a rib 'pronounced'), and possibly others. These results indicate that the cognitive approach can distinguish between certain groups of technological behaviours such as percussion and pressure flaking.

Control over the variations outlined above could be achieved in a number of ways. One approach would be to broaden the data base: the production and analysis of a greater number of flake scars representing each behaviour, the production of more experimental collections (each made from a specific raw material), and the use of the talents of numerous flintknappers would provide enough data to improve the confidence level. Subjectivity can also be lessened by quantifying some of the attribute values. Work toward that goal with the help of the Reflex Metrograph is already underway. Quantifications of this sort (e.g. ratio of height over width of a rib to determine whether it is 'indistinct', 'moderately distinct', or 'pronounced') will help standardize the coding of morphological attributes. Quantification will also permit the use of statistical manipulations.

Some research in the field of computerization would also facilitate the practical application of the cognitive approach. Computer processing of the coded data would greatly accelerate the analytical procedure. This trend could lead, eventually, to computerized coding and probabilistic behaviour identification by the computer on the basis of flake scar attributes. This could be done with the help of equipment such as the 'video imagery' system described in the Introduction.

This thesis also went beyond the correlations between behaviour and attribute (see Research Model diagram in Introduction) by delving into theories on the behaviour of force waves in solids. It was concluded that some basic force wave mechanics theories might very well explain why certain behaviours yield the morphological detail they do. These explanations, however, do not purport to be complete, and much more work needs to be done in this field before a reasonable level of confidence can be reached.

This contribution to the cognitive approach to the study of stone tools will, it is hoped, provide a stepping stone from which further studies can evolve. It should, for instance, give physicists, engineers, or geologists a basis from which to explore further the relationship between the behaviour of force waves in stone artifacts, and the physical characteristics they leave behind. From this and other such studies, the relationship between cognition, behaviour, and material culture can be better understood.

Notes

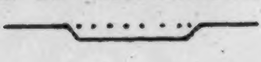
-1- These numbers have since been changed to fit a global system of material and behaviour classification established by the Project for the Study of Material Culture (University of Alberta, Department of Anthropology). All numbers used in this work refer to the new classification system.

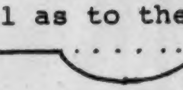
-2- "visible" includes those bulbs whose distinctiveness is "distinct" and "intermediate".

-3- Length refers to total length of the flake scar; depth refers strictly to the area outside the bulb of force.

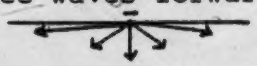
-4- "force level" refers to the amount of force used by the flintknapper when removing flakes. For definition of other terms see glossary.

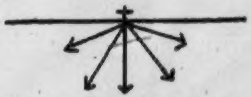
-5- The actual amount of material removed may not differ much between a flat curve and a straight edge, but with a flat curve, a deeper bite ~~is~~ taken out of the platform (as opposed to, perhaps, a wider bite for a straight edge) making it appear as though more material was removed



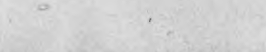


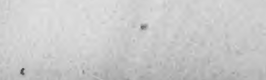
A greater amount of force seems to permit the thrusting of more force waves forward:





Thus the degree of platform collapse refers as much to the direction of the removal of material as to the amount.





-6- N.B. While the shearing and abrading techniques remove multiple, very small, overlapping flakes, amounting sometimes to no more than a powder, the rub buffet technique permits the removal of discrete flakes of somewhat larger size (very minimal to minimal size). This feature makes the rub buffet units different from the other edge units.

-7- The edge units considered here include all shearing units, pressure rub, rub abrade, and rub buffet.

-8- If microflakes are present, the ribs are close together and evenly spaced, and the distal edge is irregular, the flake was probably produced by the 'moderate shear thin with pressure flaker' technique. If, on the other hand, the ribs are moderately pronounced or pronounced, 'minimal shear thin with pressure flaker' is likely to have been used. If there are no microflakes, the ribs are indistinct, close together, located on the distal half of the flake scar, and the distal edge of the flake scar is either rounded or irregular, however, the flake could have been produced by minimal or moderate shear thin with pressure flaker.

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GLOSSARY

AMPLITUDE - Vertical distance between highest and lowest levels of a force wave. A wave of greater amplitude has a longer trajectory to cover in the same amount of time as a wave of less amplitude. (see Fig. 9)

ANGLE (of flaking tool to artifact) - The angle created by the flaking tool and the axis of the artifact. Helps determine the direction of force waves within the artifact. (See Appendix II B, Section 2, Subsection 3 (1) b)).

BEHAVIOUR - Particular method used to remove a flake from an artifact or preform (e.g. 'minimal percussion thinning with antler billet' is a behaviour which involves the removal of a flake using a minimal amount of force, the percussion technique, and an antler billet in order to remove a long, thin flake intended to thin the artifact.)

BILLET - Tubular antler percussion tool, usually with one rounded end.

BULB (of percussion or of force) - Conical indentation of variable size at the proximal end of the flake scar.

- -Bulb distinctiveness: whether the bulb can be seen clearly ('distinct'), is somewhat difficult to see ('intermediate'), or cannot be seen at all ('not visible') (see Table 1).
- -Bulb size: -length: ratio of bulb length to maximum length of flake scar (see Table 1).
  - -depth: estimated or calculated depth of bulb.

COBBLE (or HAMMERSTONE) - Small rounded stone used as a percussion tool (or as an abrading tool if the cobble is split: the split surface is the abrading surface).

Cont'd

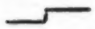
COMPRESSION (WAVE) - Incoming force wave sent through the artifact by the flaking tool. Becomes a 'tension' wave when it is reflected (see Fig. 6).

DISTAL SHAPE (or Flake scar shape at distal edge) - The shape of the distal edge of a flake scar. May be 'rounded', 'straight', or 'irregular' (see Table 1).

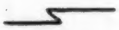
DYNAMIC LOADING (or IMPULSE LOADING) - Situation where the force is rapidly transmitted to the surface of the material. The type of loading associated with percussion flaking.

EDGE DAMAGE (or Proximal margin damage) - Any stepping, hinging, shattering, or imbedded flakes observed along the proximal margin of a flake scar; caused by the force applied in this area by the flaking tool (see Table 1).

-Stepping: tiny step(s) along the margin

side view 

-Hinging: similar to stepping but top section is undercut

side view 

-Shattering: area of crushing of the stone

-Imbedded flakes: tiny scales where very small flakes were produced on the platform surface of the removed flake but did not completely come off

EDGE PRESS ON ANVIL - Flaking technique where the flakes are removed by pressing the edge of an artifact against a large stone.

EDGE SHARPNESS (or Sharpness of proximal edge) - Whether the edge of the flake scar is 'sharp', 'intermediate', or 'dull' to the touch (see Table 1).

Cont'd

EDGE UNITS - Includes the shearing and rub units. Flaking behaviours produced by using low levels of force and affecting only the proximal margin of the artifact.

EXPERIMENTAL COLLECTION - Collection of bifaces made by a modern-day flintknapper. Each biface edge bears the flake scars produced by a specific flintknapping technique (or behaviour). These are produced for analytical purposes (e.g. Knife River flint experimental collection).

FAILED SCARS - Scars that do not correspond to the aim of the flintknapper.

-Platform crushing: platform area crumbles and the flake scar is not of the desired type.

-Many tries: the flintknapper is unable to remove the desired type of flake on first attempt and goes over the same area repeatedly until he is successful.

-Wrong force: the flintknapper uses more force than intended and the resulting flake scar is larger than intended.

FLAKE SCAR - The negative imprint of the removed flake on the artifact.

FORCE (LEVEL) - Approximate amount of force used with a particular method when removing a flake. Can be 'minimal', 'moderate', or 'substantial'.

FORCE WAVES - Waves sent through the artifact by the action of the flaking tool. The incoming force waves are referred to as 'compression' waves. These are reflected as 'tension' waves. When compression and tension waves meet, a zone of stress is created which, if strong enough, will lead to fracture (see Fig. 6).

Cont'd

FREE SURFACE - As the force wave reaches the distal edge of the stone tool, it encounters a 'free surface' (air) and is reflected back into the stone (see Fig. 6).

GRAMMAR - Set of rules of flintknapping that become habitual in the accomplished flintknapper. These rules include the type of behaviours each craftsman prefers to use for specific purposes, and the order in which he uses them. Once a flintknapper has become skillful, his grammar is fairly static and not altered very often or easily.

HAMMERSTONE - See COBBLE

INDIRECT PERCUSSION - A flaking technique where an antler billet resting in a specific area of the artifact's edge, is hit by a second antler billet. The resulting flakes are usually larger than direct percussion flakes.

INTER-GROUP SIMILARITY INDEX - Average number of correlations between technological groups such as pressure, percussion, and edge units. The correlations refer to the number of attribute states shared by two behaviours.

INTERNAL COHESION INDEX - Average number of attribute correlations shared by the behaviours making up a single technological group (e.g. percussion, or pressure, or edge unit group).

MICROFLAKES - Series of tiny edge indentations seen on the proximal edge of the flake scar and produced during the removal of the flake (see Table 1).

MINIMAL UNIT - Includes all behaviour units using minimal amounts of force only (or moderate in shearing), such as the edge units and the minimal pressure and percussion units (e.g. 'minimal pressure shape').

Cont'd

MORPHOLOGY (or ATTRIBUTES) - Physical characteristics (and their state) seen on the surface of flake scars (e.g. edge damage, bulb of force, etc.).

MOVING THE EDGE IN - Removing a portion of the artifact's edge in order to alter the shape of the artifact, straighten the edge, or to remove unwanted projections.

PERCUSSION - A flaking technique where flakes are removed by hitting the edge of the artifact with a percussor (cobble or antler billet).

PLATFORM COLLAPSE (or Morphology of the proximal edge of the flake scar) - Whether any portion of the platform was removed during flake removal. The extent of platform collapse is represented by the shape of the proximal edge. Increases from 'straight' to 'flat curve' to 'U-shaped notch' proximal edge shape (see Table 1).

PLATFORM PREPARATION - Re-touching of an edge in order to prepare it for flaking. May involve the removal of unwanted projections, thickening of the edge in order to avoid platform collapse, or a number of other types of platform prepatation. Often done with the help of an edge unit.

PRESSURE - A flaking technique where flakes are removed simply by applying pressure to the desired area with a pointed antler (or at times copper) pressure flaking tool.

PRESSURE RUB - "Rubbing across the edge with the tip of a pointed tool such as a pressure flaker; usually the artifact is held flat so the pressure rub can be applied downward"... (Young and Bonnichsen, 1984: 31). One of the edge units.

Cont'd

RE-SHARPENING - Removing flakes from a dulled edge in order to sharpen it again.

RIBS - (Also known in the literature as 'ripples'). Visible waves that extend from the proximal to the distal edge of a flake (usually outside the bulb of force). These waves are perpendicular to the direction of the incoming force waves and are the direct result of the interference (meeting) of the stress waves. Ribs may be present on some flakes but not on others. The percentages listed in Table 1 (Attribute #4.1) refer to the number of flake scars exhibiting ribs on an experimental artifact flaked with the use of a single technique (also referred to as 'rib prevalence' in the text) (see Table 1).

-Distinctiveness: refers to the size (height) of the visible ribs on an individual flake scar. Distinctiveness of the ribs may be 'indistinct' (faint), 'moderately distinct', pronounced', or may vary from one scar to the next on the same flake scar.

-Spacing: refers to the location of the ribs (on the distal half or across the entire flake scar) and to their spacing (close together or relatively far apart).

RUB ABRADE - "Rubbing the edge of the artifact with a back and forth movement, parallel to the edge, with an abrasive tool such as a rock (grinder)". (Young and Bonnichsen, 1984: 31) One of the edge units.

RUB BUFFET - "Dragging a tool such as the flat side of an antler across the edge of an artifact". (Young and Bonnichsen, 1984: 31) One of the edge units.

SCAR SIZE - Dimensions of the flake scar.

-Length: ratio of flake scar length to maximum width of the artifact at that point (see Attribute #1.1 in Table 1).

-Depth: depth of the flake scar measured at the mid-point between the end of the bulb and the distal edge of the scar in the Reflex Metrograph collection (only).

Cont'd

SHAPING - The removal of flakes from the immediate margin of an artifact in order to alter the outline (shape) of that artifact. Shaping flakes usually overlap in order to produce an even (straight) new edge.

SHEARING - Flaking technique belonging to the 'edge unit' group. Performed by "pressing the flat side of a tool against the artifact edge and slowly twisting it (either perpendicularly or diagonally) across the edge" (Young and Bonnichsen, 1984: 30).

STATIC LOADING - Situation where the force is applied to the solid over a relatively long period of time. The type of loading associated with pressure flaking.

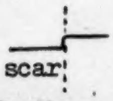
STRESS - The amount of force per unit area created by the meeting of incoming (compression) and reflected (tension) waves within the solid.

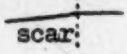
SUPPORT SYSTEM - The manner in which the flintknapper holds the artifact being flaked and the strength of such support (see Appendix II B, Section 2, Subsection 3 (1) c)).

TEARING - Short, parallel lines along or near the edges of the flake scar (see Table 1).

TENSION (WAVE) - The force wave after it is reflected back into the stone upon encountering a free surface (see Fig. 6, and COMPRESSION WAVE).

TERMINATION - Refers to the gradient of the flake scar at its extreme distal shape as it meets the unflaked surface of the artifact. (see Table 1)

- -Step: abrupt termination forming a 'step' 

- -Feathered: gradual termination that simply feathers out 

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THINNING - The removal of long, thin flakes intended to thin the artifact or to remove protruding ridges from the surface of the artifact.

APPENDIX I

TABLES I-1 TO I-6

TABLE I-1

BASIC RESEARCH DESIGN FOR EXPERIMENTAL ARTIFACTS

EDGE RUB:

1. (i) Rub abrade with cobble
   (ii) Rub buffet with cobble

2. (i) Rub buffet with antler billet
   (ii) Pressure rub with antler pressure flaker

SHEAR THIN:

3. (i) Minimal shear thin with antler pressure flaker
   (ii) Minimal shear thin with cobble (grinder)

4. (i) Moderate shear thin with antler pressure flaker
   (ii) Moderate shear thin with cobble (grinder)

SHEAR SHAPE:

5. (i) Minimal shear shape with antler pressure flaker
   (ii) Minimal shear shape with cobble (grinder)

6. (i) Moderate shear shape with antler pressure flaker
   (ii) Moderate shear shape with cobble (grinder)

PRESSURE THIN:

7. (i) Minimal pressure thin with antler pressure flaker
   (ii) Moderate pressure thin with antler pressure flaker

8 - Substantial pressure thin with antler pressure flaker

PRESSURE SHAPE:

9. (i) Minimal pressure shape with antler pressure flaker
   (ii) Moderate pressure shape with antler pressure flaker

PERCUSSION THIN WITH BILLET:

10. (i) Minimal percussion thin with antler billet
    (ii) Moderate percussion thin with antler billet

11. - Substantial percussion thin with antler billet

Cont'd

TABLE I-1, Cont'd

PERCUSSION SHAPE WITH BILLET:		
12.	(i)	Minimal percussion shape with antler billet
	(ii)	Moderate percussion shape with antler billet
PERCUSSION THIN WITH COBBLE:		
13.	(i)	Minimal percussion thin with cobble
	(ii)	Moderate percussion thin with cobble
14.	-	Substantial percussion thin with cobble
PERCUSSION SHAPE WITH COBBLE:		
15.	(i)	Minimal percussion shape with cobble
	(ii)	Moderate percussion shape with cobble
INDIRECT PERCUSSION THIN:		
16.	(i)	Moderate indirect percussion thin
	(ii)	Substantial indirect percussion thin
FLUTING:		
17.	-	Pressure flute
18.	-	Direct percussion flute
19.	-	Indirect percussion flute
RESHARPENING:		
20.	(i)	Pressure over pressure
	(ii)	Percussion over pressure
21.	(i)	Pressure over percussion
	(ii)	Percussion over percussion
OTHER:		
50	-	Edge press on anvil

TABLE I-2: KNIFE RIVER FLINT EXPERIMENTAL COLLECTION - SUMMARY

		EDGE RUB			
		Rub Abrade	Rub Buffet		Pressure Rub
		Cobble 1i	Cobble 1ii	Billet 2i	Pr. Fl. 2ii
1.0 Flake Scar Size Attributes:					
	1.1 flake scar size	VERY MINIMAL	VERY MINIMAL	VERY MINIMAL	VERY MINIMAL
2.0 Flake Scar Proximal Edge Attributes:					
	2.1 edge sharpness	DULL	INTERM.*	INTERM.	SHARP
	2.2 proximal margin damage	ABSENT	MOD. (but small)	MOD.	MOD.
	2.3 micro-flakes	ABSENT	RARE	ABSENT	ABSENT
	2.4 edge morphology	STRAIGHT	STRAIGHT	STRAIGHT	STR: 55% (FL. C.: 36-41%)
	2.5 platform collapse	PRESENT	PRESENT	PRESENT	PRESENT
3.0 Flake Scar Profile Attributes:					
	3.1 distinctiveness of bulb	NOT VISIBLE	NOT VISIBLE	NOT VISIBLE	NOT VISIBLE
	3.2 bulb size	X	X	X	X
4.0 Flake Scar Interior Morphology Attributes:					
	4.1 ribs: presence	RARE	RARE	MODERATE	MODERATE
	4.2 ribs: distinctiveness	(VAR: mostly INDIST) (only 1 case)	IND. & MOD. (only 2 cases)	IND. & VAR (only 2 cases)	MOD. & IND. (only 3 cases)
	4.3 ribs: spacing	(CL. & E.) (only 1 case)	(not enough useable)	(CL. & D½/ VAR.) (only 2)	(CL. & E./ CL. & D½) (only 2)
	4.4 tearing	ABSENT	ABSENT	ABSENT	ABS./RARE
5.0 Flake Scar Distal Edge Attributes:					
	5.1 shape	ROUND (some STR.)	STR./ RD.	VAR (RD., STR., & IRR.)	ROUNDED
	5.2 termination	FEATHER	FEATHER	FEATHER & STEP	FEATHER

*See Table 1 regarding abbreviated terms

Cont'd

TABLE I-2, Cont'd

	SHEAR THIN			
	Minimal		Moderate	
	Pr. Fl. 3i	Cobble 3ii	Pr. Fl. 4i	Cobble 4ii
1.0 Flake Scar Size Attributes:				
1.1 flake scar size	VERY MINIMAL	VERY MINIMAL	VERY MINIMAL	VERY MINIMAL
2.0 Flake Scar Proximal Edge Attributes:				
2.1 edge sharpness	SHARP	SHARP	SHARP	SHARP
2.2 proximal margin damage	LIMITED	EXTENSIVE	LIMITED	EXTENSIVE
2.3 micro-flakes	ABSENT	ABSENT	RARE/LIM.*	RARE/LIM.
2.4 edge morphology	STRAIGHT	STRAIGHT	STRAIGHT	FL.C.: 48% STR.: 38%
2.5 platform collapse	ABS.: 58% PRES.: 42%	ABS.: 52% PRES.: 48%	PRES.: 55% ABS.: 45%	PRESENT
3.0 Flake Scar Profile Attributes:				
3.1 distinctiveness of bulb	NOT VISIBLE	NOT VIS. (DIST.: 22%)	NOT VISIBLE	NOT VIS. (DIST.: 30%)
3.2 bulb size	X	X	X	X
4.0 Flake Scar Interior Morphology Attributes:				
4.1 ribs: presence	MODERATE	MODERATE	MODERATE	EXTENSIVE
4.2 ribs: distinctiveness	VARIABLE (all 3)	mostly INDISTINCT	INDISTINCT	INDISTINCT
4.3 ribs: spacing	CLOSE & DISTAL ½	CLOSE & EVEN	CL. & E./ CL. & D½ (only 3 cases)	VARIABLE (CL. & D½, CL. & E., F. & D½)
4.4 tearing	ABSENT	ABSENT	ABSENT	ABSENT
5.0 Flake Scar Distal Edge Attributes:				
5.1 shape	mostly RD. (38% STR.)	VAR. (RD., STR., IRR.)	VAR. (STR., RD., IRR.)	IRREGULAR/ ROUND
5.2 termination	FEATHER	STEP	FEATHER	STEP

* See Table 1 regarding abbreviated terms

Cont'd

TABLE I-2, Cont'd

	SHEAR SHAPE			
	Minimal		Moderate	
	Pr. Fl. 5i	Cobble 5ii	Pr. Fl. 6i	Cobble 6ii
1.0 Flake Scar Size Attributes:				
1.1 flake scar size	VERY MINIMAL	VERY MINIMAL	VERY MINIMAL	VERY MINIMAL
2.0 Flake Scar Proximal Edge Attributes:				
2.1 edge sharpness	SHARP	DULL	SHARP	DULL
2.2 proximal margin damage	RARE	EXTENSIVE	MODERATE	EXTENSIVE
2.3 micro-flakes	LIMITED	RARE	ABSENT	ABSENT
2.4 edge morphology	STR.: 55%* (FL. C.: 36%)	STRAIGHT	STRAIGHT/ FLAT CURVE	STRAIGHT
2.5 platform collapse	PRES.: 50% ABS.: 42%	ABSENT	PRESENT	PRESENT
3.0 Flake Scar Profile Attributes:				
3.1 distinctiveness of bulb	NOT VISIBLE	NOT VISIBLE	VARIABLE (NOT VIS., DIST., INT.)	INTERM.
3.2 bulb size	X	X	MINIMAL	MODERATE/ MINIMAL
4.0 Flake Scar Interior Morphology Attributes:				
4.1 ribs: presence	MODERATE	EXTENSIVE	EXTENSIVE	VERY EXTENSIVE
4.2 ribs: distinctiveness	MODERATE / INDISTINCT	INDISTINCT	INDISTINCT	VAR. (mostly IND. to MOD.) (also MOD., IND. & VAR.)
4.3 ribs: spacing	CLOSE & DISTAL $\frac{1}{2}$	CL. & D$\frac{1}{2}$/ CL. & E	CLOSE & DISTAL $\frac{1}{2}$	mostly CL. & E (some CL & D$\frac{1}{2}$ also)
4.4 tearing	RARE	RARE	ABSENT	ABSENT
5.0 Flake Scar Distal Edge Attributes:				
5.1 shape	STRAIGHT	ROUNDED	VARIABLE (RD., IRR., STR.)	VARIABLE (RD., IRR., STR.)
5.2 termination	FEATHER & STEP	FEATHER	FEATHER	FEATHER

* See Table 1 regarding abbreviated terms

Cont'd

TABLE I-2, Cont'd

	PRESSURE THINNING		
	Minimal 7i	Moderate 7ii	Substantial 8
1.0 Flake Scar Size Attributes:			
1.1 flake scar size	VERY MINIMAL	MINIMAL/ MODERATE	MINIMAL/ MODERATE
2.0 Flake Scar Proximal Edge Attributes:			
2.1 edge sharpness	SHARP	SHARP	SHARP
2.2 proximal margin damage	LIMITED	MODERATE/ EXTENSIVE	LIMITED/ MODERATE
2.3 micro-flakes	LIMITED (very small)	LIMITED (VERY SMALL)	LIMITED
2.4 edge morphology	STRAIGHT: 44% FLAT CURVE: 44%	FLAT CURVE	U-SHAPED NOTCH: 46% FL. C*: 31%
2.5 platform collapse	PRESENT	PRESENT	PRESENT
3.0 Flake Scar Profile Attributes:			
3.1 distinctiveness of bulb	NOT VISIBLE	$\frac{1}{2}$ NOT VIS. $\frac{1}{2}$ DIST.	INTERM. & DISTINCT
3.2 bulb size	X	VARIABLE (V.MIN to SUBST.) (only 2 cases)	MODERATE/ SUBSTANTIAL
4.0 Flake Scar Interior Morphology Attributes:			
4.1 ribs: presence	RARE to LIMITED	MODERATE/ EXTENSIVE	EXTENSIVE
4.2 ribs: distinctiveness	INDISTINCT (only 1 case)	INDISTINCT (only 2 cases)	INDISTINCT
4.3 ribs: spacing	(none useable)	CLOSE & EVEN/ CLOSE & DIST.$\frac{1}{2}$ (only 2 cases)	VARIABLE (CL.& E., CL. & D$\frac{1}{2}$, F & D$\frac{1}{2}$)
4.4 tearing	ABSENT OR RARE	ABSENT	LIMITED
5.0 Flake Scar Distal Edge Attributes:			
5.1 shape	VARIABLE (STR., IRR., RD.)	STRAIGHT/ IRREGULAR	STRAIGHT/ IRREGULAR
5.2 termination	STEP AND FEATHERED	STEP	STEP

* See Table 1 regarding abbreviated terms

Cont'd

TABLE I-2, Cont'd

	PRESSURE SHAPE	
	Minimal 9i	Moderate 9ii
1.0 Flake Scar Size Attributes:		
1.0 flake scar size	VERY MINIMAL	VERY MINIMAL
2.0 Flake Scar Proximal Edge Attributes:		
2.1 edge sharpness	SHARP	SHARP
2.2 proximal margin damage	MODERATE	MODERATE
2.3 micro-flakes	ABSENT	LIMITED
2.4 edge morphology	FLAT CURVE: 46% STRAIGHT: 31%	FLAT CURVE
2.5 platform collapse	PRESENT	PRESENT
3.0 Flake Scar Profile Attributes:		
3.1 distinctiveness of bulb	NOT VISIBLE	VARIABLE (DIST., NOT VIS.,* INTERM.)
3.2 bulb size	X	MODERATE/ MOD.-SUBST./ VERY SUBST.
4.0 Flake Scar Interior Morphology Attributes:		
4.1 ribs: presence	LIMITED	EXTENSIVE
4.2 ribs: distinctiveness	INDISTINCT (only 2 cases)	VARIABLE (IND., and VAR.)
4.3 ribs: spacing	CLOSE & DISTAL ½	CLOSE & EVEN/ CLOSE & DISTAL ½
4.4 tearing	ABSENT	ABSENT
5.0 Flake Scar Distal Edge Attributes:		
5.1 shape	IRREGULAR	VARIABLE (STR., RD., IRR.)
5.2 termination	FEATHERED	FEATHERED

*See Table 1 regarding abbreviated terms

Cont'd

TABLE I-2, Cont'd

	PERCUSSION THINNING WITH BILLET		
	Minimal 10i	Moderate 10ii	Substantial 11
1.0 Flake Scar Size Attributes:			
1.1 flake scar size	MINIMAL	VARIABLE (mostly V. MIN* MIN. & MOD.)	VERY SUBSTANTIAL to SUBSTANTIAL
2.0 Flake Scar Proximal Edge Attributes:			
2.1 edge sharpness	SHARP	SHARP	SHARP
2.2 proximal margin damage	EXTENSIVE	EXTENSIVE	VERY EXTENSIVE
2.3 micro-flakes	ABSENT	LIMITED	ABSENT
2.4 edge morphology	½ STRAIGHT ½ FLAT CURVE	STRAIGHT: 56% FLAT CURVE: 44%	U-SHAPED NOTCH/ FLAT CURVE
2.5 platform collapse	ABSENT: 50% PRESENT: 25% PARTIAL: 25%	PRESENT	PRESENT
3.0 Flake Scar Profile Attributes:			
3.1 distinctiveness of bulb	½ NOT VISIBLE ½ DISTINCT	NOT VISIBLE	VARIABLE (NOT VIS., INTERM., DIST.)
3.2 bulb size	SUBSTANTIAL/ VERY SUBSTANTIAL	X	VARIABLE (MIN., MOD., SUB.)
4.0 Flake Scar Interior Morphology Attributes:			
4.1 ribs: presence	MODERATE/ EXTENSIVE	MODERATE	VERY EXTENSIVE
4.2 ribs: distinctiveness	INDISTINCT/ MODERATE (only 2 cases)	VARIABLE (IND. to PRON.)	VARIABLE (IND. to MOD.-PRON.)
4.3 ribs: spacing	CLOSE & DISTAL ½ (only 1 case)	CLOSE & DISTAL ½	CLOSE & DISTAL ½
4.4 tearing	ABSENT	LIMITED	ABSENT or LIMITED
5.0 Flake Scar Distal Edge Attributes:			
5.1 shape	IRREGULAR	IRREGULAR	ROUNDED
5.2 termination	FEATHERED	STEP	FEATHERED

*See Table 1 regarding abbreviated terms

Cont'd

TABLE I-2, Cont'd

	PERCUSSION SHAPE WITH BILLET	
	Minimal 12i	Moderate 12ii
1.0 Flake Scar Size Attributes:		
1.1 flake scar size	VERY MINIMAL	VERY MINIMAL/ MINIMAL
2.0 Flake Scar Proximal Edge Attributes:		
2.1 edge sharpness	SHARP	SHARP
2.2 proximal margin damage	EXTENSIVE	EXTENSIVE
2.3 micro-flakes	ABSENT	RARE
2.4 edge morphology	STRAIGHT: 50% FLAT CURVE: 40%	STRAIGHT
2.5 platform collapse	PRESENT	PRESENT
3.0 Flake Scar Profile Attributes:		
3.1 distinctiveness of bulb	NOT VISIBLE	VARIABLE (DIST.* INTERM., NOT VIS)
3.2 bulb size	X	VARIABLE (mostly V.SUB. & MOD.)
4.0 Flake Scar Interior Morphology Attributes:		
4.1 ribs: presence	LIMITED	MODERATE
4.2 ribs: distinctiveness	PRONOUNCED (only 1 case)	INDISTINCT
4.3 ribs: spacing	(none useable)	CLOSE AND DISTAL $\frac{1}{2}$ (only 2 cases)
4.4 tearing	ABSENT	ABSENT
5.0 Flake Scar Distal Edge Attributes:		
5.1 shape	ROUNDED	ROUNDED
5.2 termination	FEATHERED & STEP	FEATHERED

* See Table 1 regarding abbreviated terms

Cont'd

TABLE I-2, Cont'd

	PERCUSSION THINNING WITH COBBLE		
	Minimal 13i	Moderate 13ii	Substantial 14
1.0 Flake Scar Size Attributes:			
1.1 flake scar size	VERY MINIMAL/ MINIMAL	VARIABLE (all categories but SUBST.)*	VERY SUBSTANTIAL / SUBSTANTIAL
2.0 Flake Scar Proximal Edge Attributes:			
2.1 edge sharpness	SHARP	SHARP	SHARP
2.2 proximal margin damage	MODERATE	MODERATE	VERY EXTENSIVE
2.3 micro-flakes	ABSENT	ABSENT	MODERATE
2.4 edge morphology	STRAIGHT	FLAT CURVE	FLAT CURVE
2.5 platform collapse	PRESENT	PRESENT	PRESENT
3.0 Flake Scar Profile Attributes:			
3.1 distinctiveness of bulb	VARIABLE (NOT VIS., INTERM., DIST.)	DISTINCT	DISTINCT
3.2 bulb size	VARIABLE (MIN., MOD., V. SUBST.)	VARIABLE (MIN-MOD, V. SUBST.)	VARIABLE (MIN., SUBST.)
4.0 Flake Scar Interior Morphology Attributes:			
4.1 ribs: presence	EXTENSIVE	MODERATE	VERY EXTENSIVE
4.2 ribs: distinctiveness	MODERATE	VARIABLE (IND. to PRON., and VAR.)	VARIABLE (MOD., MOD-PRON, VAR.)
4.3 ribs: spacing	CLOSE & EVEN/ CLOSE & DIST.½ (only 2 cases)	CLOSE & EVEN/ CLOSE & DIST½ (only 3 cases)	CLOSE & EVEN
4.4 tearing	ABSENT	RARE	LIMITED to MODERATE
5.0 Flake Scar Distal Edge Attributes:			
5.1 shape	IRREGULAR	VARIABLE (STR., RD., IRR.)	ROUNDED/ IRREGULAR
5.2 termination	STEP/ FEATHERED	FEATHERED (ST.: 39%)	STEP/ FEATHERED

*See Table 1 regarding abbreviated terms

Cont'd

TABLE I-2, Cont'd

	PERCUSSION SHAPE WITH COBBLE	
	Minimal 15i	Moderate 15ii
1.0 Flake Scar Size Attributes:		
1.1 flake scar size	VERY MINIMAL	mostly MODERATE (to MINIMAL)
2.0 Flake Scar Proximal Edge Attributes:		
2.1 edge sharpness	SHARP	SHARP
2.2 proximal margin damage	EXTENSIVE	MODERATE
2.3 micro-flakes	ABSENT	ABSENT
2.4 edge morphology	FLAT CURVE: 58% STRAIGHT: 42%	$\frac{1}{2}$ STRAIGHT $\frac{1}{2}$ FLAT CURVE
2.5 platform collapse	PRESENT	PRESENT
3.0 Flake Scar Profile Attributes:		
3.1 distinctiveness of bulb	VARIABLE (NOT VIS./ DIST.)*	VARIABLE (mostly INTERMEDIATE)
3.2 bulb size	VERY SUBSTANTIAL	MODERATE
4.0 Flake Scar Interior Morphology Attributes:		
4.1 ribs: presence	LIMITED	VERY EXTENSIVE
4.2 ribs: distinctiveness	VARIABLE (MOD. & PRON.) (only 2 cases)	INDISTINCT
4.3 ribs: spacing	FAR APART & ON DISTAL $\frac{1}{2}$ (only 1 case)	CLOSE AND EVEN
4.4 tearing	ABSENT	RARE
5.0 Flake Scar Distal Edge Attributes:		
5.1 shape	IRREGULAR/ ROUNDED	ROUNDED/ IRREGULAR
5.2 termination	FEATHERED	FEATHERED

* See Table 1 regarding abbreviated terms

Cont'd

TABLE I-2, Cont'd

	INDIRECT PERCUSSION THINNING		RE-SHARPENING:	OTHER: EDGE PRESS ON ANVIL
	Moderate 16i	Substantial 16ii	Press/Press. 20i	50
1.0 Flake Scar Size Attributes:				
1.1 flake scar size	VARIABLE (all categ.)	VERY SUBST.*	MINIMAL/ V. MINIMAL	VERY MINIMAL
2.0 Flake Scar Proximal Edge Attributes:				
2.1 edge sharpness	SHARP	mostly SHARP	SHARP	SHARP
2.2 proximal margin damage	EXTENSIVE	EXTENSIVE	LIMITED	MODERATE/ EXTENSIVE
2.3 micro-flakes	ABSENT	MODERATE	MODERATE	EXTENSIVE
2.4 edge morphology	FLAT CURVE	$\frac{1}{2}$ STRAIGHT $\frac{1}{2}$ FL. CURVE	FLAT CURVE	$\frac{1}{2}$ STRAIGHT $\frac{1}{2}$ FL. CURVE
2.5 platform collapse	PRESENT	1 ABSENT 1 PRESENT 1 PARTIAL	PRESENT	PRESENT
3.0 Flake Scar Profile Attributes:				
3.1 distinctiveness of bulb	VARIABLE (mostly DIST. some INTERM)	VARIABLE (DIST. & NOT VIS.)	NOT VISIBLE	NOT VISIBLE
3.2 bulb size	VARIABLE (MIN. to V. SUBST.)	VARIABLE (MIN., SUB., V. SUBST.)	X	X
4.0 Flake Scar Interior Morphology Attributes:				
4.1 ribs: presence	VERY EXTENSIVE	VERY EXTENSIVE	VERY EXTENSIVE	MODERATE
4.2 ribs: distinctiveness	MODERATE	IND-MOD/ VAR (3 cases)	INDISTINCT	INDISTINCT
4.3 ribs: spacing	CL. & E./ CL. & D$\frac{1}{2}$	CL. & E./ CL. & D$\frac{1}{2}$/ VAR.	CL. & E./ CL. & D$\frac{1}{2}$	CL. & E./ CL. & D$\frac{1}{2}$
4.4 tearing	ABSENT	VERY EXTENSIVE	RARE	RARE
5.0 Flake Scar Distal Edge Attributes:				
5.1 shape	VARIABLE (IRR., STR., RD.)	VARIABLE (STR., IRR., RD.-IRR.)	IRREGULAR	VARIABLE (STR., RD., IRR.)
5.2 termination	STEP / FEATHERED	STEP / FEATHERED	FEATHERED	FEATHERED/ STEP

* See Table 1 regarding abbreviated terms

TABLE I-3

GUIDELINES FOR BEHAVIOURS' COMPOSITE PICTURES

ATTRIBUTE STATE %	RATING	PROCEDURE
100% 81 - 99% 61 - 80%	:exclusive :almost exclusive :substantial	:if one attribute state shows a rating of substantial or better (i.e. 61-100%) and is accompanied by other attribute states rated minimal or less (0-40%): only the state (value) showing a substantial or better rating is to be used in the composite picture
41-60%	:moderate	:if one moderate and some minimal or less ratings were tabulated: use judgment (e.g. -60:40% : use only the 60% value -45:35% : use both)
21 - 40% 1 - 20%	:minimal :very minimal	:if all attribute states observed showed minimum or less ratings: no clear pattern observed; indicate attribute state as variable and list all attribute states included

N.B. If only a few flake scars were analyzed (1 to 3-6) and their values for a particular attribute did not clearly fall under one particular attribute state, list all attribute states in the composite picture (i.e. variable) (eg. 5 flake scars: 2 showing rounded distal edges, 2 showing irregular distal edges and one showing a straight distal edge: categorize this behaviour as resulting in irregular or rounded or straight distal edges)

TABLE I-4: LAKE ABITIBI WELDED TUFF DATA: SUMMARY (Pollock, 1984)

	PERCUSSION BILLET	PERCUSSION COBBLE	PRESSURE PRESS. FL.	SUMMARY - ⟶ +
1.0 Flake Scar Size Attributes:				
1.1 flake scar size				
2.0 Flake Scar Proximal Edge Attributes:				
2.1 edge sharpness	SHARP	SHARP	SHARP	
2.2 proximal margin damage	MOD. to EXT.	MOD. to V. EXT.	LIM. to MOD.	PR B/C
2.3 micro-flakes				
2.[illegible] edge morphology	FLAT CURVE	FLAT CURVE	U-SHAPED NOTCH	B/C PR
2.5 platform collapse				
3.0 Flake Scar Profile Attributes:				
3.1 distinctiveness of bulb	NOT VISIBLE	NOT VISIBLE	NOT VIS. ("pinched when vis.)	C/B/PR
3.2 bulb size	Length: Longer	Length:	Length:	Length: B
	Depth: Deeper	Depth:	Depth:	Depth: B
4.0 Flake Scar Interior Morphology Attributes:				
4.1 ribs: presence	ABS, LIM, or MOD.	ABS or LIM.	ABS/RARE	PR C B
4.2 ribs: distinctiveness	IND.	IND.	IND.	PR/B/C
4.3 ribs: spacing	F&D½ (often 2 dist. ridges near termin.)	FAR & EVEN	CLOSE & EVEN	
4.4 tearing				
5.0 Flake Scar Distal Edge Attributes:				
5.1 shape	RD. & STR.	STR.	RD. (some STR & IRR.)	C: STR. B: RD & STR PR: RD.
5.2 termination	FEATH. & STEP	STEP	FEATH. (some ST.)	C:ST; PR:F; B: F & ST

*See Table 1 regarding abbreviated terms

TABLE I-5: GEORGETOWN FLINT DATA: SUMMARY (Young and Bonnichsen, 1984)

	PERCUSSION COBBLE	PERCUSSION THIN BILLET	PRESSURE THIN PRESS. FL.	PRESSURE SHAPE PRESS. FL.
1.0 Flake Scar Size Attributes:				
1.1 flake scar size	mostly MIN.*	increases with force	increases with force	V.MIN to MIN.
2.0 Flake Scar Proximal Edge Attributes:				
2.1 edge sharpness	SHARP	SHARP	SHARP	relatively SHARP
2.2 proximal margin damage	shape: EXT. thin: MOD.	EXT.	RARE to MODERATE	MOD. to VERY EXT.
2.3 micro-flakes	thin: more shape: less		most at mod. force	LIM. to MOD.
2.4 edge morphology	FLAT CURVE	FLAT CURVE	from STR/FL.C to FL.C/U-NOTCH with force	FLAT CURVE
2.5 platform collapse				
3.0 Flake Scar Profile Attributes:				
3.1 distinctiveness of bulb	less often than press. or billet	more often than cobble		
3.2 bulb size	flatter (climb out of bulb is more gradual)	rapid climb out of bulb		
		bit broader than press. bulb	"pinched" at proximal end	
4.0 Flake Scar Interior Morphology Attributes:				
4.1 ribs: presence	EXT.	MOD. to EXT. with force	LIM. to EXT with force	approx. MOD.
4.2 ribs: distinctiveness	IND.	IND. (1 or 2 PRON. near termination)	IND.	IND.
4.3 ribs: spacing	Thin: F & VAR Shape: VAR	CL & E to VAR. with force	CL & EVEN	CL & EVEN (often F & D½ also)
4.4 tearing				
5.0 Flake Scar Distal Edge Attributes:				
5.1 shape	STR. or RD.	STR. to STR/RD with force	STR/RD to STR with force	VAR. (mostly STR. or RD.
5.2 termination	FEATH.	FEATH. (bit ST with force	FEATH. to ST. with force	FEATH. mostly

*See Table 1 regarding abbreviated terms

TABLE I-6: REFLEX METROGRAPH DATA : SUMMARY

THINNING ONLY FORCE: TECHNIQUE: TOOL:	I SUBSTANTIAL PERCUSSION BILLET	II SUBSTANTIAL PERCUSSION COBBLE	III SUBSTANTIAL PRESSURE PRESS. FL.	SUMMARY - → +
1.0 Flake Scar Size Attributes:				
1.1 flake scar size	10-57 mm. avg. 33.4 median: 33	25-42 mm. avg. 30 mm median: 29	9-16 mm. avg. 12.3 median: 12	PR C B
2.0 Flake Scar Proximal Edge Attributes:				
2.1 edge sharpness				
2.2 proximal margin damage		V.EXT * (5/6 or 83%)	EXT. (5/7 or 71%; bit)	PR C
2.3 micro-flakes				
2.4 edge morphology	FL.C (63%) (STR. 17% U-N. 17% IRR. 4%)	FL.C (100%) (one is very deep)	FL.C: 50% U-N: 50%	B C PR
2.5 platform collapse				
3.0 Flake Scar Profile Attributes:				
3.1 distinctiveness of bulb	12/14 are visible	all are visible	6/7 are visible	
3.2 bulb size	Length: SUB.: 38% MOD.: 38% MIN.: 25%	Length: SUB.: 57% MOD.: 29% V.SUB: 14%	Length: MOD.: 43% SUB.: 43% MIN.: 14%	Length:
	Depth: .07-.2 mm avg: .11 median: .1 & .11	Depth: .07-.14 mm avg: .11 median: .11 & .13	Depth: .03-.19 mm avg: .12 median: .11 & .13	Depth:
4.0 Flake Scar Interior Morphology Attributes:				
4.1 ribs: presence	EXT-V.EXT (64-90%)	V.EXT (100%)		B C
4.2 ribs: distinctiveness	PRON: 68% MOD-PRON: 29% VAR.: 4%		IND.: 50% IND-MOD, MOD-PRON: 20%@ PRON: 10%	PR B
4.3 ribs: spacing	F&E: 75% F&D$\frac{1}{2}$: 12.5%) VAR: 12.5%		mostly FAR apart	
4.4 tearing				
5.0 Flake Scar Distal Edge Attributes:				
5.1 shape	very few STR.	very few STR.	very few RD.	
5.2 termination			STEP: 71%	

*See Table 1 regarding abbreviated terms

APPENDIX II

ANALYSIS OF KNIFE RIVER FLINT EXPERIMENTAL COLLECTION

APPENDIX II

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APPENDIX II

ANALYSIS OF KNIFE RIVER FLINT EXPERIMENTAL COLLECTION

A) Analysis of artifacts:

As stated in the chapter on methodology, Robson Bonnichsen struck off a number of flakes from the edges of seventeen prepared Knife River flint bifaces. He used a single behaviour to produce the flakes from one edge of each of the preforms. In other words, all the flakes removed from one particular edge of a specific biface were produced by the same behaviour. The successful and reasonably complete flake scars from each of the 31 behaviours represented in the collection were analysed using a coding system based on 14 flake scar attributes and their values or states (see Fig. 5, and Table 1).

B) Analysis of data:

The aforementioned analysis of the Knife River flint experimental collection was condensed to form the basis from which the composite picture of a typical flake scar from each of the 31 behaviours was obtained. From these composite pictures, comparisons between individual behaviours and broader categories of behaviours (e.g. pressure vs percussion) were made. The results were based on selected attributes judged to be more diagnostic than others. Explanations for some of these observations will be attempted in chapters II and III.. Tables II-1 to II-44 may be found at the end of this Appendix.

SECTION 1: BEHAVIOURS

Subsection 1: Comparisons within behaviour groups

(1) Thinning:

a) percussion thinning:

i) with billet (see Table II-1)

Percussion thinning creates considerable edge damage (extensive/very extensive) even at lower force levels. -4- The extent of the damage increases with increasing force. Rib prevalence follows a slightly different course: ribs are most prevalent when substantial force is applied, moderately prevalent at moderate force levels, but slightly more prevalent again (moderate to substantial) at minimum force levels. Ribs are generally fairly prevalent in percussion thinning with billet (moderate to substantial). Substantial amounts of force tend to remove more material than lower force levels, as revealed by the shape of the proximal edge of the flake scar: flat curve at substantial force levels, straighter edge at moderate and minimal levels. In other words, there is more platform collapse with increased force. -5-

ii) with hammerstone (see Table II-2)

The extent of edge damage and prevalence of ribs follows the same pattern, with reference to force levels, as in percussion thinning with billet. The degree of edge damage, however, is not as extensive as with the antler billet. The bulb of percussion is more often visible at moderate and substantial force levels than when using a minimum amount of force. The flat-curved proximal edge is produced by a moderate or substantial blow. A lesser amount of force removes less material from the platform area, resulting in a straight edge (see footnote -5-).

percussion thinning - summary:

Percussion thinning produces a considerable amount of edge damage (moderate to very extensive) which increases with force. Ribs are relatively prevalent at all force levels (moderate to very extensive). They are most prevalent at substantial force levels but less prevalent at moderate than at minimum levels of force. The amount (or forward direction, i.e. depth of curve) of platform collapse correlates with the use of increased force by the flintknapper. This collapse, however, occurs at lower force levels with the hammerstone than with the antler billet. This fact would indicate less force is required to remove the same amount of material with the hammerstone than with the billet. The billet, on the other hand, produces more visible edge damage than the hammerstone. The bulb of percussion is somewhat more noticeable with hammerstone work than with billet work.

The amount of material removed and the amount of edge damage appear to be related to the tool used. The hammerstone takes more of the platform away, thus removing the potentially damaged edge.

a) pressure thinning: (see Table II-3)

The amount of force used by the flintknapper in pressure thinning determines the frequency with which ribs will be seen on the flakes (rare to limited at minimal force level, moderate to extensive at moderate force level, and extensive at substantial force level). It does not, however, affect the distinctiveness of the ribs, which remain indistinct at all force levels. Greater force does not only produce ribs more often, it also produces more platform collapse (from straight/flat curve at minimal force levels, to flat curve at moderate force levels, to U-shaped notch at substantial force levels); and increases the chances of the bulb of percussion being visible. When visible, the bulb is a good size (moderate to substantial). Edge damage is greatest at moderate force levels, lesser at substantial force levels, and is least evident at minimum force levels.

Thinning - summary

Ribs can be present at all force levels in thinning flakes. The greater the force used by the flintknapper, the more of the platform area will collapse, resulting in proximal edges that are more and more concave with increasing force levels.

percussion vs pressure:

Percussion thinning results in slightly more edge damage than does pressure thinning (limited-moderate-extensive vs moderate-extensive). While an increase in force is parallelled by an increase in the extent of edge damage in percussion thinning (see Tables II-1 and II-2), the greatest amount of edge damage in pressure thinning is found at moderate force levels, is lesser at substantial force levels, and least at minimal force levels (see Table II-3).

Ribs are visible more often with percussion thinning (moderate to very extensive) than with pressure (rare-limited to extensive). Although rib prevalence increases with force in pressure thinning, it is found to be greater at substantial and minimal force levels and least at moderate force levels in percussion thinning.

Pressure thinning gives rise to a greater degree of platform collapse than does percussion (straight or flat curve for percussion vs 1/2-straight/1/2-flat curve, or flat curve, or U-shaped notch for pressure) (see Table II-3). This collapse is also evident at lower levels with pressure thinning (already present at minimal force level) than with percussion (collapse begins with moderate force levels with the hammerstone, but not until substantial force levels with the billet).

Note that as more of the platform is removed, less edge damage remains (see Tables II-1, II-2, and II-3):

pressure thinning:	more platform collapse less edge damage
percussion thinning:	less platform collapse more edge damage

	platform collapse	edge damage
pressure:	+	-
percussion: - hammerstone:	↑	↓
- billet:	-	+

No particular patterns were observed for thinning in general with regard to the bulb of percussion. Some of Young's experiments using the reflex metrograph, however, have shown that some differences should have been present (e.g. hammerstone work creates longer bulbs) (Personal communication, David Young, 1986)

(2) Shaping:

a) percussion shaping:

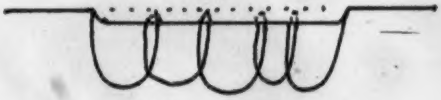
i) with billet (see Table II-4)

In percussion shaping with billet, an increase in the amount of force used by the craftsman invariably leads to the following results. It increases the possibility of edge damage from extensive, at minimal force levels, to very extensive at moderate force levels (N.B.: substantial force is not used in percussion or pressure shaping). It causes an increase in the prevalence of ribs (from limited to moderate) accompanied by a decrease in the distinctiveness of these ribs (i.e. ribs are larger at minimal force level). It also increases the chance of the bulb being visible: the bulb is rarely visible when using minimal amounts of force but can be when using moderate strength.

Shaping is intended to 'move in' the edge of the tool (see glossary) by removing some material. The fact that no platform collapse was observed would seem to indicate that most of the flakes failed to do what the flintknapper set out to do. For an explanation see Subsection 2 (1) below.

ii) with hammerstone (see Table II-5)

Although with different results, increased strength affects a number of variables in hammerstone shaping as well. It produces a sizeable increase in rib prevalence (from limited to very extensive), although the size of the ribs is generally smaller with increased force levels. It is also associated with a decrease in the extent of edge damage (although the latter is at least moderate at either force level) and with a noticeable decrease in the size of the bulb. The presence or absence of the bulb varies at both force levels (i.e. bulb can be either not visible, moderately visible, or visible). Although the proximal edges of the flake scars do not exhibit much curvature, platform collapse is actually quite extensive. The overlapping of flakes has removed the lateral edges of most flakes, therefore straightening the edge of the artifact as well as the edge of each flake scar.



Slightly more curvature is, however, visible with increased force.

percussion shaping - summary:

Edge damage is at least moderate at all force levels in percussion shaping. While rib prevalence increases with increased force, rib distinctiveness follows the opposite path and decreases with increased force. Because of the shaping nature of the behaviours, platform collapse should have been observed in the form of a curved proximal edge. The flakes produced by billet failed to show this feature. The flakes produced by the hammerstone also showed straighter edges than expected, but this feature was explained by the fact that overlapping flakes removed the lateral sides of most flakes, changing flat curves to straight edges. Platform collapse is to be expected, therefore, in percussion shaping.

The use of the billet in shaping generally results in more edge damage than the use of the hammerstone. The presence of damage increases with increased force in billet but decreases with hammerstone work. The bulb of percussion may be visible at any force level with the hammerstone but may only be visible when using moderate force with the billet. That is to say, minimal percussion shaping with antler billet very rarely produces a visible bulb of percussion. Ribs are present more often on flakes produced with the hammerstone than the billet.

a) pressure shaping: (see Table II-6)

In pressure shaping, increased force is responsible for an increased prevalence of ribs, and, to a certain extent, an increase in rib distinctiveness. It also brings about slightly more platform collapse (from a mixture of straight edges and flat curves to flat curves only), and adds to the likelihood of seeing a bulb of force. When visible, the bulb is relatively large (very minimal/minimal: 10%, moderate: 35%, substantial/very substantial: 55%; therefore 90% of visible bulbs are moderate to very substantial in size). Edge damage is not affected by differential application of force, and remains moderate at both levels.

Shaping - summary

'Shaping flakes' in general produce a moderate amount of edge damage. Platform collapse is (or should be) present but never extends beyond a flat curved proximal flake edge. A slight increase with increased force is observed, however. Rib prevalence also increases with force, and the percentages at each force level are fairly constant regardless of tool or flaking method used (limited in all cases at minimal force levels; moderate or very extensive for percussion and extensive for pressure at moderate force levels).

percussion vs pressure:

Percussion shaping tends to produce more edge damage than does pressure shaping (moderate to very extensive vs moderate). The frequency with which damage occurs in pressure shaping is not affected by changes in the amount of force applied to the pressure flaker. This is not the case in percussion shaping, however, where damage increases with force when using the billet and decreases with force in the case of the hammerstone.

Platform collapse increases from percussion with billet (straight edge and no collapse in the Knife River flint experimental artifacts) to percussion with hammerstone (some curvature of the proximal edge observed, although obscured by overlapping of flakes (see above)), to pressure shaping where (flat) curved proximal edges are not uncommon. Increased platform collapse is also associated with increased force (except for percussion with billet). Collapse is evident at lower force levels (minimal) in pressure shaping than in percussion shaping (hammerstone: moderate force level; billet: no collapse apparent because of flake overlap).

When it comes to rib distinctiveness or size, pressure and percussion shaping behave in opposite ways: distinctiveness increases somewhat with force in pressure shaping but decreases in percussion shaping.

Hammerstone shaping produces bulbs of percussion more often than does billet percussion, or pressure shaping. The size of bulbs varies, but larger bulbs (substantial to very substantial) are found only in flakes produced by minimal percussion shape with hammerstone or moderate percussion shape with billet.

As with thinning flakes, platform collapse and absence of edge damage are related. In fact, it follows exactly the same pattern as for thinning flakes (see Tables II-4, II-5, II-6).

pressure: more platform collapse
less edge damage
percussion: less platform collapse
more edge damage

		platform collapse	edge damage
pressure:		+	-
percussion:	- hammerstone:	↑	↓
	- billet:	-	+

(3) Edge Units:

a) shearing - thinning:

i) with pressure flaker (see Table II-7)

Shear thinning with pressure flaker produces no visible bulbs, little edge damage (limited) and a moderate prevalence of ribs. Except for ribs, which are slightly more distinguishable at lower force levels, the degree of force used by the craftsman does not affect the outcome. No platform collapse was observed, most likely because of the straightening of the flakes' edges by overlapping flakes (see percussion shaping with hammerstone).

ii) with cobble (see Table II-8)

Shear thinning with cobble produces slightly different results. Increased force levels lead to a greater prevalence of ribs (although indistinct at either level), and the appearance of visible platform collapse. Again the proximal edge of each flake scar was probably straightened by overlapping scars, giving the illusion of no or little platform collapse. The bulb of percussion is not visible, and the edge damage is extensive. These last two attributes are not affected by the amount of force used.

shear thinning - summary:

Shear thinning, regardless of tool used, produces no visible bulb of force. Ribs are present relatively often (moderate) and are most prevalent (extensive) on flakes made by the moderate shear thinning with cobble method. The ribs are indistinct except for minimal shear thin with pressure flaker which creates ribs of variable sizes. Because of the overlapping of flakes, little or no platform collapse is visible. It does seem to occur at lower force levels when using the cobble rather than the pressure flaker, however. The use of the cobble also results in much more edge damage than is caused by the pressure flaker at either force level (extensive vs limited). Different force levels do not significantly affect the outcome of flake scar attributes, with the following exceptions: an increase in force using the pressure flaker results in ribs that are somewhat larger, and in an increase in rib prevalence and platform collapse when using the cobble as a shearing tool.

b) shearing - shaping:

i) with pressure flaker (see Table II-9)

At minimal force levels there are no bulbs of force, no visible platform collapse (see section on percussion shaping with hammerstone), and little or no edge damage. The application of more force results in the appearance of edge damage moderately often, an increased prevalence of ribs accompanied by a decrease in the size of these ribs, the appearance of some visible platform collapse, and of a bulb of force (sometimes visible, sometimes intermediate, and sometimes not visible at medium force levels, but rarely visible at minimal force levels). The bulb is not overly large, however, never exceeding 3/8 of the flake's length (i.e. moderate bulb size).

ii) with cobble (see Table II-10)

Shear shaping with the cobble produces extensive edge damage and the frequent presence of ribs (extensive to very extensive). The ribs are more prevalent and more distinct at higher force levels. The bulb of percussion, which is not visible at minimal force levels, becomes so at the moderate force level, although it is never larger than moderate (1/4 - 3/8 of maximum flake scar length). Platform collapse was not visible (see section on percussion shaping with hammerstone).

shear shaping - summary:

In shear shaping, the bulb of percussion is affected by the amount of force used, and does not become visible until moderate force is applied. It is also relatively small (very small to moderate) in comparison with the maximum length of each flake scar. Very few bulbs are visible at minimum force levels. Rib presence is at least moderate and increases with force, as does rib distinctiveness in shear shaping with a cobble. The distinctiveness of ribs seen on shear shaping flakes produced by the pressure flaker is, however, inversely proportional to the amount of force applied. The cobble produces ribs more frequently than does the pressure flaker. The absence of visible platform collapse in most cases was explained earlier by the overlapping of the flake scars. It becomes visible only with the application of moderate amounts of force using the pressure flaker (50% straight/50% flat curves). The cobble creates much more edge damage than does the pressure flaker (extensive vs absent/rare to moderate). While the frequency with which edge damage occurs increases with force with the pressure flaker (absent or rare, to moderate), it remains extensive at both force levels with the cobble.

shearing - summary:

The shearing behaviours do not often produce bulbs of force. Only two of the eight shearing units are characterized by visible bulbs, in both cases shaping units, and not until moderate force is used (i.e. moderate shear shape with cobble or pressure flaker). The bulb is visible or intermediate only in 84% of the flake scars when the amount of force used in shearing is minimal. When visible, the bulb is never large (very minimal to moderate).

Rib presence is at least moderate and ribs are slightly more prevalent in shear shaping than in shear thinning, as well as when using the cobble, as opposed to the pressure flaker. There is also a general tendency for an increase of rib prevalence (i.e. more flakes exhibiting ribs) with increasing force. They are perhaps slightly larger (more distinct) on shear shaping flakes, where their distinctiveness increases with force when using the cobble but decreases with force with the use of the pressure flaker.

The proximal edges of the flake scars retain their curvature only in moderate shear thin with cobble and moderate shear shape with pressure flaker, thus indicating these two shearing units produce somewhat more platform collapse than do the remaining six. Although no explanation was found for this, the above information indicates that when shear thinning an edge, platform collapse occurs earlier with the cobble; and when shear shaping, it occurs earlier with the pressure flaker.

Shearing with a cobble leaves more flakes damaged at their proximal edges than does shearing with the pressure flaker, regardless of the level of force used (extensive vs absent/rare to moderate). With the exception of shear shaping with the pressure flaker, the frequency of edge damage is not affected by increased force levels.

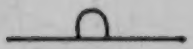
c) rub units:

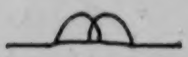
i) rub buffet-6-: with billet and with cobble (see Table II-11)

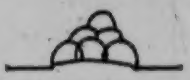
Regardless of the tool used, rub buffetting produces no platform collapse, no visible bulbs, and moderately frequent edge damage. In fact, the only attribute affected by the tool used is rib presence which is moderate with the use of the antler billet and rare with the cobble.

ii) rub abrade with cobble and pressure rub with pressure flaker (see Table II-12)

Pressure rub creates more edge damage and a greater frequency of ribs than rub abrade. The ribs, however, are never larger than moderate, and the bulb of force is rarely visible. The overlapping of flakes in rub abrade removes any apparent sign of platform collapse. The issue is slightly more complicated in the case of pressure rub. When using that technique, the flintknapper works the same small area repeatedly in order to remove material and straighten the edge of the artifact. Upon close examination it appears each small flake has a straight proximal edge. Because of the repeated application of pressure rub over the same small area, removal of material eventually occurs. A single pressure rub flake scar may not exhibit platform collapse through a concave (flat curve) proximal edge, but the small areas of concentration of these individual pressure flakes do.







rub units - summary:

The frequency of edge damage in flakes created by a rubbing technique is mainly moderate. The exception is rub-abrade which produces little or no edge damage.

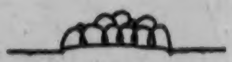
Ribs are absent or rare with the use of the cobble (rub buffet with cobble and rub abrade with cobble), and moderate with the use of the antler billet (rub buffet) or antler pressure flaker (pressure rub). When visible, the ribs are seldom pronounced (indistinct to moderate to variable).

The bulb is rarely visible in rub units. The small size of the flakes, however, makes it difficult to clearly see the morphology of the interior of the flake scars.

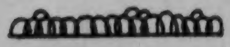
The only rubbing behaviour exhibiting signs of platform collapse is pressure rub. As described earlier the collapse is not due to one individual flake but to a series of flakes concentrated in a small area on the tool's edge.

The four rub units can be differentiated as follows:

- rub abrade flakes rarely show edge damage, while the other three rub units show damage moderately often.
- pressure rub and rub buffet with billet create ribs, which are absent or rare from rub buffet with cobble and rub abrade flakes.
- the rub buffet with billet ribs can be pronounced while the pressure rub ribs cannot.
- rub buffet produces discrete flakes.
- repeated (as it usually is), pressure rub produces a series of flakes in a determined area.



- rub abrade produces a line of overlapping tiny flake scars.



edge units - summary (includes shear and rub techniques)

The small size of edge units flakes and, in many cases, the overlapping of these small flakes, make it difficult to determine whether bulbs of force are present or not. When visible, the bulb never covers more than 3/8 of the flake's maximum length.

Rib presence is moderate or greater except for flakes issued from rub buffet with cobble, or rub abrade with cobble (absent or rare). Sixty percent of the edge units exhibit indistinct ribs, while 25% exhibit ribs that vary in size, and 15% show moderately distinct ribs. Only 10% of the edge unit behaviours produce pronounced ribs.

Platform collapse is difficult to ascertain and is apparent, although infrequently, only in moderate shear thin with cobble, moderate shear shape with pressure flaker, and in pressure rub with pressure flaker.

Edge damage varies from absent/rare to extensive (absent/rare: 17% of behaviours, limited: 17%, moderate: 33%, extensive: 33%).

Subsection 2: Comparisons between behaviour groups

(1) Thinning vs shaping behaviours vs edge units -7-

(see Table II-13)

Proximal edge damage is common in all three types of behaviours (thinning, shaping, edge units). Although lower frequencies are also encountered, in the majority of cases edge damage is found on at least 25% to 50% (i.e. coded as moderate edge damage) of all flake scars. The shaping behaviours are particularly damaging, and never produce less than moderate edge damage (i.e. damage found on 25-50% of flake scars). The edge units seem to leave the least amount of edge damage (see Table II-13):

absent-rare: 17% of tools
limited : 17% of tools
moderate : 33% of tools
extensive: 33% of tools

Thinning usually produces at least moderate edge damage, although some of the thinned edges also show limited frequencies of edge damage .

frequency of edge damage: + ————————————→ ++
edge units   thinning   shaping

In both shaping ~~and~~ thinning, percussion leaves some edge damage, more often than does pressure. The different behaviours react to increases in force in the following manner. In percussion shaping with billet and percussion thinning with either tool, the frequency of edge damage increases with increased force. In percussion shaping with the hammerstone, it decreases. In pressure thinning, damage is most frequent at moderate force levels. And in pressure shaping, the frequency of edge damage does not seem to be influenced by increased force.

Rib prevalence also varies from one type of behaviour to another. The behaviours are ranked as follows:

– ————————————→ +
shaping   edge units   thinning

- shaping: 50% of behaviours show limited frequency of ribs (i.e. ribs on 10-25% of flake scars)
- edge units: 50% of behaviours show moderate frequency of ribs (i.e. ribs on 25-50% of flake scars)
  25% of behaviours show extensive frequency of ribs (i.e. ribs on 50-75% of flake scars)

- thinning: 88% of behaviours show moderate to very extensive frequency of ribs (i.e. ribs on 25-100% of flake scars)

In thinning, the percussion techniques create ribs more often than the pressure techniques. In shaping, rib prevalence is similar for both percussion and pressure behaviours. The prevalence of ribs generally increases when more force is used, with the exception of percussion thinning where the ribs are more prevalent at minimal and substantial levels of force than they are at moderate force levels. As for the distinctiveness of the ribs, not much patterning was observed, although 60% of the ribs created by an edge unit technique are indistinct. In percussion shaping, rib distinctiveness also increased with accrued force while it decreased in pressure shaping.

The proximal edge morphology of flake scars revealed that edge curvature increases from the edge units to the shaping behaviours to the thinning behaviours. As concavity of an edge reflects the extent of platform collapse, it would appear from this information that thinning creates more platform collapse than shaping. This fact, however, is inconsistent with the nature of these types of behaviours: shaping techniques are used to remove projections, straighten, or move an entire edge in (see glossary). Thus platform collapse is intended. A closer look at the experimental tools clarified the situation: in order 'to move edges' in uniformly (see glossary), the flintknapper produced shaping flakes that were quite close to each other. The overlapping of the flakes is intended to straighten the edge, which it did, thus erasing traces of platform collapse on previous flakes (see section on percussion shaping with hammerstone).

This observation probably also applies to the edge units which show little platform collapse. Here, it is the nature of the movement itself which produces flake overlap: one movement or action produces a series of tiny overlapping flakes. For thinning, shaping, and some instances of shearing, the extent of platform collapse increases with an increase in applied force.

Among the artifacts flaked by a thinning technique, the bulb of force is either visible or variable (i.e. visible on some flake scars but not on others). The shaping techniques produced bulbs more often when they involved percussion with a hammerstone than when the shaping flakes were produced through pressure or percussion with the antler billet. On shaping flakes, larger bulbs were seen only when a percussion technique was used. The bulb of force is rarely visible on edge unit flakes. One explanation for this absence may be that the extremely small size of the edge unit flakes makes it difficult to see anything at all on them. As noted earlier, these flakes also overlap a great deal, thus covering up attributes from previous flake scars. When visible, bulbs from edge unit behaviours are of very minimal to moderate size 73% of the time (i.e. less than 3/8 of maximum flake scar length).

As expected, the thinning methods produce the longest flake scars (minimal to very substantial, and variable). Edge units and shaping behaviours both produce scars that are minimal to very minimal in size. Again, because of the nature of the behaviours, this result was predictable. One might expect, however, that when produced individually, shaping flake scars would be somewhat longer than edge unit flake scars. But such was not the case. One must keep in mind, however, that removal of the lateral edges of the shaping flake scars through overlapping of the flakes, a procedure which is intended to straighten the edge, truncates the flake scars thus, reducing their length. This also occurs in edge units, but to a lesser extent.

(2) Percussion vs pressure (see Table II-14)

In general, pressure flake scars exhibit edge damage less often than do percussion flake scars. Pressure techniques also result in more platform collapse which tends to erase traces of proximal margin damage. The frequency of edge damage increases with the application of greater force in percussion thinning and in percussion shaping with billet. On the other hand, when the hammerstone is used to produce shaping flakes, the frequency of edge damage decreases with increased force. In pressure thinning, damage is greatest when moderate levels of force are used; and in pressure shaping, the level of force does not appear to affect the frequency of proximal margin damage.

Pressure flaking, which generally produces more platform collapse than percussion, also requires less force to do so. Some degree of edge curvature, diagnostic of platform collapse, is already evident at minimal force levels in pressure; while in percussion the same degree of curvature is not observed until greater force levels are used (moderate to substantial), if seen at all.

Percussion produces ribs more often than pressure, but only when thinning flakes are being produced. In shaping, frequencies are similar for percussion and pressure. Rib prevalence tends to increase with increased force, with the exception of percussion thinning where ribs are more prevalent at minimal and substantial force levels than at moderate levels.

As for the presence of the bulb of force, the frequencies are similar for both pressure and percussion, with perhaps a slight tendency towards more bulb visibility in percussion flaking.

(3) Hammerstone vs billet percussion (see Table II-15)

The use of an antler billet produces more visible edge damage, slightly less platform collapse, and slightly less rib prevalence than does the use of the hammerstone. With the hammerstone, proximal margin damage decreases with accrued force; but with the billet shaping techniques, the presence of edge damage increases with an increase of force. Table II-15 furnishes more detail regarding the above statements.

(4) Minimal units: minimal percussion vs minimal pressure vs edge units (see Table II-16)

The minimal percussion and pressure units (e.g. minimal percussion shape with cobble, minimal pressure thin, to mention only a few) leave behind flakes of a size similar to that of the edge units. Some means of differentiating between them would therefore be useful.

The frequency with which these techniques cause damage to the proximal edges of the flakes removed differs from one technique to the next. The minimal pressure behaviours appear to leave behind the least amount of damage, although, as seen earlier, pressure also removes a great deal of the evidence by removing more of the platform than do percussion or edge units. Minimal percussion flakes bear traces of edge damage quite frequently (extensive, i.e. on 50-75% of all flake scars), and the edge units are intermediate between the minimal pressure and percussion behaviours, with moderate to extensive edge damage (25 to 75% of flake scars).

Although platform collapse is not extensive with any of these behaviours, the minimal pressure techniques still produce the greatest amount of proximal edge curvature (50% flat curve, 50% 1/2-flat curve/1/2-straight). Minimal percussion and the edge units show percentages that are very similar to each other (minimal percussion: 81% straight edges; edge units: 83% straight edges) and pointing to a very limited amount of visible platform collapse.

Ribs are seen more frequently on the edge unit flake scars, less so on the minimal percussion flake scars, and least often on the minimal pressure flakes. Minimal pressure techniques also produce the least distinctive ribs, while minimal percussion flaking produces the most distinctive (with more than half the scars exhibiting moderately pronounced to pronounced ribs). Edge unit behaviours produce ribs that are mostly indistinct, although more than a quarter of the flakes exhibit ribs that are moderately pronounced, or pronounced.

Bulbs of force were not seen very frequently on the edge units nor on the other minimal units (percussion or pressure). They were, however, observed 25% more often on minimal percussion units than on the edge units. The presence of bulbs in minimal pressure flakes is negligible. Size of the bulb of force follows the same trend, with minimal percussion techniques yielding generally much larger bulbs than the edge unit techniques.

Subsection 3: Trends

The previous sections focused on the differences between groups of behaviours such as the pressure thinning behaviours or all percussion behaviours. This next section will draw attention to the similarities between individual behaviours in the hope of establishing a pattern of relationships between all behaviours, to see how closely related each behaviour is to all the others. Thus far in this study, behaviour groupings have been based on similarities in flaking techniques (e.g. pressure vs percussion, or billet vs cobble). The information in this section will begin from the other end, and delineate clusters on the basis of attribute similarities instead. It will be interesting to see whether the two types of groupings, the first based on technique, the second on result, correspond to each other. This portion of the analysis will also separate the behaviours that are highly diagnostic from those that are not. This, again, will be done from the viewpoint of attribute states, also referred to as attribute values in the text.

(1) Strong correlations

The strongest correlation between two behaviours involves minimal shear thin with pressure flaker (behaviour

3i) and its moderate force counterpart (4i). The two behaviours have 12 of their 14 attribute states in common, a sharing which makes them the most difficult behaviours to distinguish from one another. -8-

A number of other behaviours have been termed 'popular' because they share many attribute states or values with a great number of other behaviours (see Table II-17). Because they share so many characteristics with so many other behaviours, these six behaviours are the hardest to identify with certainty. Most of these behaviours belong to the edge unit grouping, and half are shearing techniques. In fact, moderate shear thin with cobble (4ii), the only shear thinning unit not included in Table II-17, shares 9-11 out 14 attributes with 9 other behaviours. It could therefore be included in Table II-17, and we could conclude that all shear thin units share many attribute states with many other behaviours, making them harder to identify.

Calculations based on the information in Table II-18 reveal that 52% (34/66) of the relationships between all edge units show strong correlations (9-11/14 shared attribute states), while only 36% (49/136) of the relationships between other types of units show the same strong correlations with each other. In other words, the edge units have more in common with each other than do the other units. This situation makes the edge units harder to identify and to distinguish from each other.

Minimal pressure shape (9i) is also not easily distinguished from other behaviours, and particularly so from the edge units. The other minimal units (percussion or pressure, thinning or shaping) do not exhibit such correlations with the edge units.

(2) Weak correlations

The weakest correlations determine what behaviours are most easily distinguished from certain other behaviours. These pairs of behaviours share no more than three attributes:

experimental artifacts	# of attributes shared
rub buffet w. cobble & subst. pressure thin:	2 1/2
rub buffet w. cobble & subst. perc. thin w. cobble:	2 1/2
min. shear shape w. cobble & subst. press. thin:	2 1/2
min. shear shape w cobble & subst. perc. thin w cobble:	1 1/2

In fact, substantial pressure thin (behaviour #8) has fewer than 6 of 14 attributes in common with 20 of the 30 other behaviours. Its only strong connections (i.e. nine or more attributes in common) are with moderate pressure thin (7ii), moderate pressure shape (9ii), moderate percussion thin with billet (10ii), and moderate percussion thin with cobble

(13ii). In other words, substantial pressure thin is closely related only to the moderate thinning units (except for moderate indirect percussion thin (16i)) and to moderate pressure shape.

Substantial percussion thin with cobble (behaviour #14) also has fewer than 6 of the 14 attributes in common with 20 of the 30 other behaviours. The only other behaviour it is closely linked to (9-11/14 attributes shared) is its billet counterpart: substantial percussion thin with billet (behaviour #11).

The only other substantial thinning method, substantial percussion thin with billet (behaviour #11), has less than 6 of the 14 attributes in common with 12 of the 30 other behaviours, and 6 to 8 of the 14 attributes in common with 16 behaviours. Its only strong ties are with substantial percussion thin with cobble (behaviour #14), as seen above.

The substantial thinning behaviours should, therefore, be relatively easy to identify, although substantial pressure thin (behaviour #8) may be confused with one of the moderate pressure behaviours or with one of the moderate thinning (percussion or pressure) behaviours if the four or five attributes that distinguish them have been obliterated or are difficult to assess.

Five behaviours are termed 'unpopular' because they share very few attributes with many other behaviours (see

Table II-19). The information from Table II-19 confirms the earlier observation that the substantial thinning behaviours do not share many attributes with other behaviours, and are therefore the easiest to identify (although they still have some strong correlations with some of the other behaviours).

(3) Edge press on anvil; re-sharpening: pressure over pressure; indirect percussion thinning

These three types of behaviours were not included in the three basic technological groups (pressure, percussion, edge units) because they either cross-cut these technological groupings, or because there is insufficient information. Edge press on anvil may belong to the pressure or the edge unit grouping. Indirect percussion involves both percussion and pressure. No force level was recorded for the sample bearing the pressure re-sharpening flakes. The following information, based on attribute similarities, will place each of those three behaviours into the technological cluster with which they have the most in common on the basis of morphology.

a) Edge press on anvil: (see Table II-20)

Edge press on anvil is a technique whereby a flake is removed by pressing the artifact against a stone (anvil) instead of pressing a tool to the artifact as in pressure flaking. Edge press on anvil shares more attribute values with edge units than with pressure units. Although it also has a good deal in common with the minimal pressure units (thinning and shaping) and, to a lesser extent, with the moderate pressure units, edge press on anvil (behaviour #50) belongs with the edge units and will be treated as such from now on.

b) Re-sharpening: pressure over pressure: (see Table II-21)

'Re-sharpening: pressure over pressure' (behaviour #20i) shows many characteristics also seen in the minimal pressure units (thin or shape) and in some of the edge units. It should therefore be considered a minimal pressure unit that also has a fair amount in common with moderate shear thin with pressure flaker (4i) and edge press on anvil (50).

c) Indirect percussion thinning: (see Tables II-22 and II-23)

Thus far, only the strong correlations (9-11 out of 14 shared attribute values) have been considered when determining the strength of the relationships between certain behaviours (N.B.: at the other end of the scale, weak correlations (3-5 shared attributes) were also used). Indirect percussion behaviours, however, exhibit very few correlations in the 'strong' range (9-11/14). It was therefore necessary to drop one notch below into the 'moderate' correlations range in order to obtain enough numbers for comparison of pressure versus percussion in relation to indirect percussion thin. This would indicate from the start that indirect percussion thin is fairly distinctive, particularly substantial indirect percussion.

Indirect percussion thinning is closer to the direct percussion thinning behaviours than to pressure thinning (or to percussion or pressure shaping), and has more attribute values in common with cobble thinning than with billet thinning. This result is unexpected since antler billets are the tools used in indirect percussion thinning.

(4) Links between behaviour groups

a) Edge units vs pressure and percussion behaviours (see Table II-24)

As demonstrated in Table II-24, the edge units exhibit strong correlations with certain other behaviours. The behaviour that appears closest to the edge units (attribute correlations) is minimal pressure shape (9i). It shares 9 to 11 of its 14 attribute values with nearly a third of the edge units (4 of 13). Minimal pressure thin (7i), and moderate percussion shape with billet (12ii) are not far behind, each showing strong correlations with one quarter of the edge units (3 of 13). A few other pressure and percussion behaviours show a close correspondence to a couple of the edge units. These are: moderate pressure shape (9ii); minimal percussion shape with billet (12ii); moderate percussion thin with cobble (13ii); moderate percussion shape with cobble (15ii); and re-sharpening: pressure over pressure (20i).

As expected, the behaviours that resemble most closely some of the edge unit behaviours are those using only minimal, or at most, moderate amounts of force, as well as the shaping units and the minimal and moderate pressure units.

b) Percussion vs pressure: (see Table II-25)

The pressure and percussion techniques are important to this study not only because they make up nearly 60% of all the behaviours examined but also because they account for most of the flaked surfaces on prehistoric artifacts. A comparison of pressure and percussion on the basis of attribute similarity will serve to see what behaviours morphologically link these two technological clusters and why.

As Table II-25 shows, half of the strongly correlated (9-11/14 attributes in common) pressure and percussion behaviours are homologous. That is to say, half of the strongly correlated pressure and percussion behaviours differ technologically only by the fact that they belong to the pressure or percussion group. Moderate percussion thin with billet (10ii), for instance, is strongly related to its pressure homologue, moderate pressure thin (7ii). In fact, both moderate percussion thin behaviours (10ii and 13ii) are closely correlated to their pressure counterpart (moderate pressure thin (7ii)); and both minimal percussion shaping behaviours (12i and 15i) are also closely correlated to their pressure counterpart (minimal pressure shape (9i)). It appears, from this information, that when producing shaping flakes using minimal force levels, and when producing thinning flakes using moderate force levels, the use of pressure or percussion does not significantly affect the morphological outcome of the flake.

Some non-homologous pressure and percussion behaviours also show strong ties. Minimal percussion shape with billet (12i) and minimal pressure thin (7i) share 10 of the 14 attributes. As the only technological connection between these two behaviours is the use of minimal amounts of force, it would seem logical to assume that, at minimal force levels, shaping or thinning behaviours produce similar results. This assumption, however, is not totally supported by data on attribute similarities between other minimal thinning and shaping units: roughly half of the minimal thin/shape correlations are strong (9-11/14 shared attributes), but the other half shows moderate correlations (6-8/14 shared attributes).

Another strong relationship between non-homologous pressure and percussion behaviours is found between moderate percussion thin with cobble (13ii) and moderate pressure shape (9ii). This relationship is similar in nature to the previous one: the only link between these two behaviours is the amount of force used to remove the flakes.

The last example involves a strong correlation between two totally unrelated behaviours: minimal percussion thin with cobble (13i) and moderate pressure shape (9ii). No explanation for this morphological similarity comes to mind.

(5) Links within behaviour groups

This section will examine the strong and the weak correlations between behaviours belonging to the same technological group and, in concluding, will compare these to the group's correlations with other groupings to see whether the pressure, percussion, and edge unit behaviours do form clusters on the basis of their morphological effects on stone.

a) Pressure (see Table II-26)

High and low correlations between pressure behaviours are influenced more by the level of force used to produce the flakes than by any other criterion. Table II-26 shows that all strong correlations involve either forces of the same level for two otherwise different behaviours (e.g. minimal pressure thin (7i) and minimal pressure shape (9i)), or forces of adjacent levels for otherwise identical behaviours (e.g. moderate pressure thin (7ii) and substantial pressure thin (8)). At the same time, weak correlations are found between behaviours that differ greatly in force level and, in one instance, in intent (thin vs shape). Moderate pressure thin (7ii) shows a slightly higher correlation with substantial pressure thin (8) than with moderate pressure shape (9ii) (10 of 14 shared attributes with the former, and 9 of 14 with the latter). This result indicates that similarity of intent (here: 7ii and 8 are both thinning behaviours) combined with adjacent force levels result in higher correlation than sameness of force level alone.

Looking at this information from another angle, it appears that the pressure thinning and shaping behaviours produce flakes that have many characteristics in common, as long as the force level is constant, or not too different. The attributes that distinguish pressure thinning from pressure shaping are outlined in Table II-27.

b) Percussion (see Table II-28)

The role of the force level in creating particular characteristics on percussion flake scars appears to be as important as it is in pressure flaking. Table II-28 shows that 6 of the 10 strong correlations involve techniques using the same level of force, and four of the six weak correlations involve techniques using very different force levels. Adjacent force levels associated with otherwise identical behaviours also result in strong correlations between the behaviours involved. This was also shown to be the case in pressure flaking. Moreover, as shown by the weak correlations in Table II-28, a sizeable change in the amount of force used affects the morphology of the flake more than a change in intent (i.e. shaping vs thinning) or a change in tool.

Substantial percussion thin with cobble (behaviour #14) bears little resemblance to the other percussion behaviours, except for substantial percussion thin with billet (behaviour #11) (9 of 14 attributes shared). This result confirms the importance of force level in the morphological outcome of flake scars. It also shows that a difference in tool alone affects this outcome less than a large difference in force level.

Minimal and moderate percussion shaping with cobble (15i and 15ii) share many attributes (9-10 of 14) with a number of other percussion behaviours. These two behaviours will therefore be more difficult to identify, within the percussion group.

As previously shown (see Section 1, Subsection 3 (3) c) of this Appendix) , moderate indirect percussion thin produces flake scars that bear strong resemblance (9-11/14 shared attributes) only to flake scars created by the direct percussion thinning with cobble technique using either minimal or moderate force (13i and 13ii).

The data from Table II-29 outline the differences that stem from the use of the antler billet or that of the cobble in percussion, and how percussion shaping differs in morphological results from percussion thinning (N.B.: indirect percussion thinning was excluded).

c) Edge Units (see Tables II-30 and II-31)

The edge units form a tightly knit group of behaviours on the basis of resulting flake scar attributes (see also (4) a) above: 'Links between behaviour groups: a) Edge units vs pressure and percussion behaviours'). Table II-30 shows that 75% of the edge units exhibit strong (9-11/14 attributes shared) or very strong (12-13/14 attributes shared) correlations with at least half of the other edge units. The average number of attributes shared by two edge units is

8.75/14, which is 0.25 away from belonging to the 'strong correlation' category. The numerous components of Table II-30 make it difficult to see at a glance the factors responsible for correlations among units. Table II-31 was therefore drawn up to clarify the situation for the shearing units. An equivalent table for the remaining edge units was not required. Table II-31 subdivides all relationships between behaviours into those based on the use of the same tool (e.g. minimal shear thinning with pressure flaker and moderate shear shaping with pressure flaker), on the use of the same force level (e.g. minimal shear thin with pressure flaker and minimal shear shape with cobble), on the use of adjacent force (all other criteria remaining the same, e.g. minimal shear shape with cobble and moderate shear shape with cobble), on the same technological intent (i.e. thinning vs shaping, e.g. minimal shear thin with cobble and moderate shear thin with pressure flaker), on the technique of flaking alone (e.g. minimal shear thin with antler pressure flaker and moderate shear shape with cobble). The relationships with other types of behaviours are also included (e.g. shearing and rub units, or shearing and edge press on anvil).

Table II-31 shows that the choice of the tool used in shearing, or in one of the other edge units, has the greatest effect on the outcome of the flake scars. The use of equivalent levels of force also plays an important role. It should be noted, however, that the strongest correlations very often are found between behaviours sharing more than one technological characteristic. Minimal shear thin with antler pressure flaker (3i), for instance, is closest to moderate shear thin with pressure flaker (4i): these two behaviours differ in force level but are otherwise identical. With the exception of minimal shear shape with cobble (5ii), the shear thinning units generally have more attributes in common with the entire edge unit grouping than do the shear shaping units. This result is unexpected since the rub units, which make up the remainder of the edge units, help change the shape of the artifact's edge by removing projections, and help strengthen the edge of the artifact by removing the thin margin area.

While all edge units display moderate to high correlations with each other, some units show higher correlations than others. Pressure rub with pressure flaker (2ii), for example, shares 9-11/14 attributes with 11 of the other 12 edge units. This situation makes pressure rub with pressure flaker (2ii) a difficult behaviour to distinguish from the other edge units as well as from the minimal and moderate pressure and percussion shaping units. In fact, this behaviour topped the list of 'popular' behaviours (in Section 1, subsection 3 (1) of this Appendix, it shows 9-11/14 attributes in common with 17 of the 30 other behaviours, 11 of those 17 being edge units). Moderate shear thin with pressure flaker (4i) is also difficult to distinguish from other edge units. The average correlation with all 12 other edge units is 9.63/14, an average higher than that of pressure rub with pressure flaker (2ii) (9.42/14). It correlates strongly (9-11/14 shared attributes) or very strongly (12/14) with fewer edge units than does pressure rub with pressure flaker (2ii), however (9/12 for the former as opposed to 11/12 for the latter).

Moderate shear shape with cobble (6ii) shows the fewest morphological connections with other edge units. Its only strong correlations are with minimal shear shape with cobble (5ii: its adjacent force level counterpart), moderate percussion shape with billet (12ii), and moderate indirect percussion thin (16i). These last two strong relationships remain unexplained.

With the exception of the shear thinning units with cobble (3ii and 4ii), edge press on anvil (behaviour #50) does not show the strong correlations with the behaviours using a cobble as a flaking tool (1i, 1ii, 5ii, 6ii) that it does with all other edge units.

d) Conclusions

In order to see whether pressure behaviours, percussion behaviours, and the edge units do form separate groupings on the basis of morphological characteristics of the flake scars they produce as well as from a technological viewpoint, the correlations between as well as within each of these groups were used as an index of internal cohesion or of morphological similarity between groupings. Let us use the pressure group to exemplify this assertion. Of 15 possible correlations between pressure behaviours (i.e. intra-group comparisons), 5 (or 33%) are strong (9-11/14 shared attributes), 8 (or 53%) are moderate (6-8/14), and 2/15 (or 13%) are weak (3-5/14). The total of all 15 correlation values divided by 15 yielded an average correlation value of 7.77/14 shared attributes between pressure units. The index of internal cohesion for the pressure grouping is therefore 7.77. The inter-group similarity indices, in this case, involve the pressure vs percussion, and pressure vs edge units correlations. Of 72 possible correlations between pressure behaviours and edge units, 8 (or 11%) are strong, 45 (or 63%) are moderate, and 19 (or 26%) are weak. The index of similarity between the pressure grouping and the edge unit grouping (or average correlation value) is 7.23 (i.e. 7.23/14 shared attributes). Of 78 possible correlations between pressure and percussion behaviours, 16 (or 21%) are strong, 43 (or 55%) are moderate, 17 (or 22%) are weak, and 2 (or 3%) are very weak. The index of similarity between the pressure grouping and the percussion grouping is 6.72. To summarize, for the pressure grouping, the index of internal cohesion is 7.77; and the indices of inter-group similarity are 7.23 with the edge units, and 6.72 with the percussion group.

The following summarizes the above information for all three behaviour groups.

Indices	Correlations				
	very strong	strong	moderate	weak	very weak
Pressure:					
-internal cohesion index: 7.77	--	33%	53%	13%	--
-inter-group similarity indices: with edge units: 7.23	--	11%	63%	26%	--
with percussion: 6.72	--	21%	55%	22%	3%
Percussion:					
-internal cohesion index: 7.41	--	15%	76%	9%	--
-inter-group similarity indices: with pressure: 6.72	--	11%	63%	26%	--
with edge units: 6.65	--	12%	60%	28%	1%
Edge Units:					
-internal cohesion index: 8.75	1%	53%	45%	1%	--
-inter-group similarity indices: with pressure: 7.23	--	21%	55%	22%	3%
with percussion: 6.65	--	12%	60%	28%	1%

All three technological groups show internal cohesion indices that are higher than their inter-group similarity indices. This means the behaviours from each of the three technological groups generally have more morphological attributes in common with each other than they do with the other two groups. It does not necessarily follow that the strongest correlations will be between behaviours from the same technological group since the indices represent the general trend. Minimal pressure shape (9i), for example, shows stronger correlations (11/14 shared attributes) with two edge units (2ii and 6i) than it does with any other pressure unit. Yet, pressure shows generally greater internal cohesion than inter-group similarity.

The edge units show the highest degree of internal cohesion. The average intra-group correlation is 8.75, nearly a 'strong correlation' (9-11/14 shared attributes). In fact, 99% of its intra-group correlations are very strong (12-13/14 shared attributes), strong (9-11/14), or moderate (6-8/14). Morphologically, edge units, as a group or individually, appear closer to pressure units than to percussion units. This is not surprising since friction, the basic action used in all of the edge units, is more akin to pressure than to percussion.

Pressure behaviours show the second highest degree of internal cohesion. The difference between the internal cohesion index and the inter-group similarity indices, however, is not as great as that observed for the edge units. The pressure group appears, from the correlation averages, somewhat closer to the edge units (average of 7.23/14 shared attributes) than to the percussion units (average 6.72/14 shared attributes). Yet there are 10% more strong correlations between the pressure-percussion behaviours than between the pressure-edge unit behaviours. The degree of similarity between the pressure group and the percussion and edge unit groups is, therefore, very close.

The percussion group of behaviours shows less internal cohesion than the other two groups: 7.41, as opposed to 8.75 for edge units and 7.77 for pressure. The internal cohesion index still falls within the 'moderate' range (6-8/14 shared attributes), however, and is higher than either inter-group similarity index (6.72 for pressure, 6.65 for edge units). Percussion appears somewhat more similar to pressure than to the edge units.

SECTION 2: ATTRIBUTES

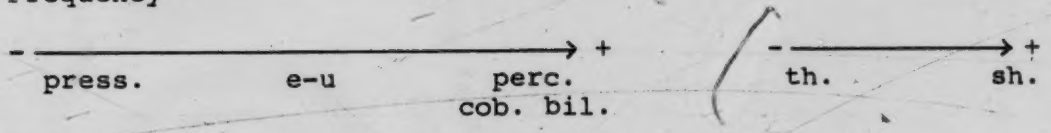
Subsection 1: Facts about certain attributes

(see Tables II-32 and II-33, and Section 1,
Subsection 2 (1) of this Appendix)

The previous sections have dealt with similarities and differences between behaviours based on the attributes, or more precisely on the attribute states seen on the flake scars they produce. Now we turn to the attributes themselves to see how, within the confines of each of the three technological groups, they react to an increase in force level; how they differ from one technological group to the next; and how they are affected by the flintknapper's intention to thin an artifact or to shape it. For reasons explained earlier, the emphasis will be placed on the pressure and percussion techniques. The contrast between the thinning and shaping behaviours, for instance, represents the pressure and percussion behaviours only. The differences between percussion with the billet and percussion with the cobble will also be taken into account.

(1) Edge damage (attribute #2.2 in Table 1)

Frequency*:



Frequency with increased force:
-pressure: -thinning: least at minimal force, more at substantial force, greatest at moderate force ↗↘
-shaping: similar frequency at all force levels ⟷
-percussion: -cobble: -thinning: increases ⟶
-shaping: decreases ⟵
-billet: -thinning and shaping: increases ⟶
-edge units (shearing only): similar frequency at either force level ⟷

(*: '-' : lowest frequency; '+' : highest frequency; press.: pressure group; perc.: percussion group; cob.: percussion behaviours using a cobble; e-u: edge units group; bil.: percussion behaviours using an antler billet; th.: thinning behaviours; sh.: shaping behaviours)

Percussion flaking results in edge damage more often than do the edge units or pressure flaking behaviours (moderate to very extensive for percussion; mostly moderate to extensive for edge units; and mostly limited to moderate for pressure). Within the percussion group, billet work causes edge damage more often than does the cobble (substantial in 80% of percussion behaviours using billet, moderate in 60% of percussion behaviours using a cobble).

The thinning behaviours appear to cause somewhat less edge damage than the shaping units (limited to moderate or more vs moderate or more). The degree of edge damage visible on a flake scar is related to the amount of platform collapse that occured on the flake. This phenomenon will be explored further in Subsection 2, ~~on~~ attribute associations.

With the exception of percussion shaping with the cobble, an increase in force level generally results in more frequent edge damage when using a percussion technique. In pressure flaking, however, the likelihood of seeing edge damage on the flake is greatest at moderate force levels, lesser at substantial force levels, and least at minimal force levels. Edge damage does not appear to be much affected by force level in shearing.

(2) Platform collapse (attributes #2.4 and 2.5 in Table 1)

The data accumulated under attribute #2.5 'platform collapse' indicate most behaviours result in some degree of platform collapse. The extent of this collapse is represented by attribute #2.4 'morphology of proximal edge of flake scar': the greater the edge curvature (concave), the deeper the bite into the platform. Thus platform collapse increases from a 'straight' proximal edge, to a 'flat curve', to a 'U-shaped notch'.

Frequency (see * under (1) Edge damage, above):

- ——————————————→ + - ——————→ +
e-u perc. press. sh. th.
bil. cob.

Timing **:
last first last first
- ——————————————→ + - ——————→ +
e-u perc. press. sh. th.
bil. cob.

Frequency with increased force:
-pressure: increases ————→
-percussion: increases ————→ (except shaping with
billet: same at all force levels) ←————→
-edge units (shearing only): increases ————→

(**: Timing refers to the force level at which platform collapse (i.e. rounded proximal edges) becomes consistently apparent. Here, for instance, the pressure behaviours result in platform collapse at a lower force level than do the edge units or the percussion behaviours. The '-' or 'last' end of the arrow therefore represents the greater end of the force level spectrum, while the '+' or 'first' end of the arrow can be equated with the lesser end of the force level spectrum)

The degree of platform collapse appears to be affected by the amount of force used: the greater the force, the greater the platform collapse. Only the percussion shape with billet behaviours (12i and 12ii) do not conform to this pattern. The data from studies of other raw materials will determine whether this exception is meaningful, or whether it is peculiar only to Knife River flint, or simply erroneous.

The frequency and extent of platform collapse increases from edge units (shearing) to percussion with billet, to percussion with cobble, to pressure. More than 50% of the proximal edges seen on flakes produced by shearing (65%) and percussion with the billet (53%) are straight, while the billet produces flat curves in 58% of cases. Pressure flaking results in the greatest frequency of U-shaped notches. Less force is required in pressure than in percussion flaking, and in cobble than in billet percussion, to create curved proximal edges. Thus, pressure behaviours cause the greatest amount of platform collapse, followed by the percussion with cobble behaviours, while billet percussion causes the least visible collapse. Shearing results in numerous small overlapping flakes, a condition which, as seen earlier, flattens the proximal edges of individual flake scars, thus erasing the signs of platform collapse. The original extent of platform collapse occasioned by the shearing technique cannot, therefore, be assessed.

When the thinning and shaping behaviours were compared, it was observed the thinning flakes show greater edge curvature than the shaping flakes. This contradicts the fact that shaping flakes are intended to remove material from the edges of the tool (as opposed to the surface of the tool as in thinning) and, therefore, should remove more of the platform area than thinning flakes. A closer look at the experimental tools showed the shaping flakes overlap, probably in an effort by the flintknapper to straighten entire segments of an edge. As in shearing, the overlapping of the shaping flakes results in removal of the flakes' lateral edges and in a flattening of the individual flakes' edge curvature (see Section 1, Subsection 2 (1) of this Appendix). The appearance of more platform collapse in thinning than in shaping flakes is, therefore, misleading. Shaping should create more platform collapse than thinning, but which of these two types of behaviours actually does cause more platform collapse cannot be determined from the Knife River flint experimental collection because of the overlapping of the shaping flakes. It should also be noted that because of the purpose they serve, shaping flakes will exhibit less proximal edge curvature than the thinning flakes in archaeological samples as well.

(3) Ribs:

a) rib presence: (attribute #4.1 in Table 1)

Frequency (see * under (1) Edge damage, above):

- ⟶ +   - ⟶ +
** e-u   press.   perc.   sh.   th.
bil.   cob.
(**: actual order was difficult to ascertain)

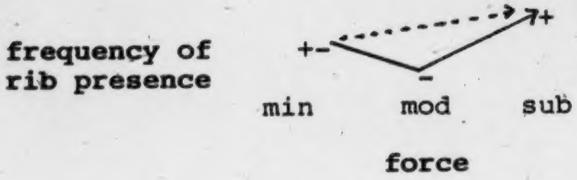
Frequency with increased force:
-percussion thinning (billet and cobble): least at moderate force, greater at minimal force, greatest at substantial force level
-percussion shaping (billet and cobble): increases ⟶
-pressure (thinning and shaping): increases ⟶
-edge units (shearing only): increases ⟶

The frequency of ribs on flake scars is generally high: 67% to 85% of the behaviours show a moderate to very extensive rib frequency (i.e. ribs on 25-100% of flake scars). Ranking of the behaviours on the basis of rib presence frequency was difficult to determine. The following can be taken as one interpretation of the data.

The percussion behaviours when taken as a whole produce ribs on the surface more often than do the pressure behaviours or the edge units. When the techniques using the billet and cobble are considered separately, however, it becomes apparent that billet percussion does not produce ribs quite as often as percussion with the cobble or even than pressure flaking. The edge units, perhaps because of the diminutive size of their flakes, do not reveal ribs quite as often as do the other types of behaviours.

When it comes to the presence of ribs, there is a definite difference, however, between the thinning and the shaping behaviours. Thinning produces ribs on 25% to 100% of the flake scars (moderate to very extensive) in 88-92% of cases (the second number includes shear thinning, the first number does not) while shaping produces the same range of rib presence frequency in 50-70% of cases (the second number includes shear shaping, the first does not). In other words, 30-50% of the shaping units exhibit ribs on less than 25% of their flake scars, while this happens in only 8-12% of the thinning units.

There is a general trend for greater prevalence of ribs to be associated with increased force in percussion and pressure flaking, as well as in shearing. A deviation from this general pattern is observed only in percussion thinning, where the use of moderate force reduces the chance of seeing ribs. But even in percussion thinning, the application of substantial force results in greater frequency of rib presence than does the application of minimal amounts of force.



:general trend for greater prevalence of ribs with increased force

At minimal force levels in shaping, whether through percussion or pressure techniques, the frequency of ribs is always 'limited' (i.e. ribs seen on 10-25% of flake scars). It then increases with the application of greater force in increments dependent on flaking technique and tool: more so for percussion shaping with cobble, less for pressure shaping, and least for percussion shaping with antler billet.

b) rib distinctiveness: (attribute #4.2 in Table 1)

Frequency (see * under (1) Edge damage, above):

- ————————————→ + press. e-u perc. bil. cob.

- ————→ + sh. th.

Distinctiveness with increased force:
-pressure: -thinning: similar at all force levels ⟷
-shaping: slight increase ⟶
-percussion: -billet: -thinning: least distinct at minimal force level, slightly more distinct with substantial force, most distinct at moderate force levels. ↗↘
-shaping: decreases ⟵
-cobble: -thinning: similar at all force levels ⟷
-shaping: decreases ⟵
-edge units (shearing only): slight decrease ⟵

Ribs appear to be generally larger, or more distinct, on percussion flakes than on edge unit or pressure flakes. In percussion, the type of flaking tool used affects the size of the ribs: the use of the cobble results in ribs that are more prominent than those produced by billet percussion. The thinning behaviours create 'moderately pronounced' and 'pronounced' ribs more often (17% more often when shearing is included and 30% more often when it is not) than the shaping behaviours.

Generalizations about the manner in which rib distinctiveness responds to increased force by the flintknapper cannot be all-encompassing. Increased force when thinning a tool does not greatly affect the distinctiveness of the ribs, except for percussion thinning with the billet when rib distinctiveness is greater at substantial force than at minimal force levels and greatest at moderate force levels. When shearing, or when shaping a tool by pressure or percussion, the use of increased force results in a lessening in the distinctiveness of the ribs. Pressure shaping is the exception to this rule, however: here, an increase in force is accompanied by a slight increase in rib distinctiveness.

c) rib spacing: (attribute #4.3 in Table 1)

			Force Level	
		min.	**mod**	**subst**
press.:	: thinning:	(not enough data)	CL & D 1/2* CL & E	CL & E CL & D 1/2 F & D 1/2
	shaping:	CL & D 1/2	CL & D 1/2 CL & E	
perc.: billet:	thinning:	CL & D 1/2	CL & D 1/2	CL & D 1/2
	shaping:	CL & D 1/2	CL & D 1/2	
cobble:	thinning:	CL & D 1/2 CL & E	CL & D 1/2 CL & E	CL & E
	shaping:	**(F & D 1/2)	CL & E	
edge units:	shearing:	CL & D 1/2 CL & E	CL & D 1/2 CL & E	
	rub units and edge press on anvil:	CL & D 1/2 CL & E		
- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
thinning:		CL & D 1/2 CL & E	CL & D 1/2 (CL & E)***	CL & E CL & D 1/2
shaping:		CL & D 1/2	CL & E	CL & D 1/2

(*: CL & D 1/2: ribs are close together and located on distal 1/2 of flake scar
CL & E: ribs are close together and evenly distributed across the entire flake scar, outside the bulb of force
F & D 1/2: ribs are farther apart and located on distal 1/2 of flake scar)
(**: based on information from one flake scar only; may not be representative of behaviour)
(***: ( ): less, but still well represented)

Billet percussion creates ribs that are close together and generally found at the distal end of the flake scar. With the cobble, ribs are also close together, and at minimal force levels may be found either on the distal end or on the entire face of the flake scar; while increased force finds them more and more scattered across the entire flake scar (i.e. evenly distributed). In pressure, the dominating rib spacing types are 'close and evenly distributed' and 'close and on distal half'. As in percussion with the cobble, an increase in force in pressure flaking tends to scatter the ribs more evenly across the flake scar. The edge units generate ribs that are close together, and found either on the distal end of the flake scar or evenly distributed across the surface of the flake scar. In general, the thinning unit flake scars show equal proportions of evenly distributed ribs, and of ribs located on their distal half. The great majority of ribs seen on the Knife River flint experimental samples were closely spaced.

Ribs: Comment

The effect of force waves on the production, distinctiveness, and spacing of ribs will be investigated in chapter III. B). There, some explanations for the phenomena observed above will be attempted.

(4) Bulb of force:

a) distinctiveness (attribute #3.1 in Table 1)

(i.e. presence or absence of bulb)

Frequency of bulb visibility:

- ⟶ +   - ⟶ +

e-u   press   perc.   sh.   th.

bil. cob.

Amount of force (required to create a bulb):

last ⟶ first   last ⟶ first

(most amount of force required)   e-u   press.   perc.   bil. cob.   (least amount of force required)   th.   sh.

Distinctiveness with increased force:
-pressure: increases ⟶
-percussion: -cobble: increases ⟶
-billet: increases ⟶
-edge units (shearing only): increases somewhat ⟶

The use of the cobble in flake removal by percussion results in the creation of distinct bulbs of force more often than the use of the billet or than pressure flaking, or one of the edge unit methods. Pressure flaking and percussion with the billet yield bulb presence frequencies that are quite similar.

Percussion with cobble probably results in visible bulbs of force most often because it requires the least amount of force to create a bulb, as indicated in the 'amount of force' diagram above. This pattern fits all other behaviours as well: the least amount of force required to produce a distinct bulb of force, the greater the actual frequency of a visible bulb. This relationship between bulb frequency and amount of force required to create a bulb is not evidenced in the comparison between thinning and shaping behaviours. A possible explanation might be that the frequencies of bulb presence for these two groups of behaviours are fairly close.

It appears, therefore, that the likelihood of seeing a bulb of force is directly related to the amount of force used by the flintknapper in removing flakes. This relationship is confirmed by a general trend for greater bulb visibility associated with an increase in force level, a trend to which all behaviour groups conform.

b) size: (attribute #3.2 in Table 1)

Size:

smaller → larger: e-u, press., perc. bil./cob.

smaller → larger: th. sh.

Size with increased force:
-pressure: -thinning: similar size ⟷
-shaping: size increases →
-percussion: -billet: -thinning: similar at moderate and substantial force levels, smaller at minimal force level ⟷
-shaping: size increases →
-cobble: -thinning: smallest at moderate force level, larger at substantial force, largest at minimal force
-shaping: size decreases ←
-edge units (shearing only): similar size ⟷

The pressure and percussion techniques yield bulbs of force of a similar size; that, is generally large, ranging mostly from moderate to very substantial (1/4 to more than 1/2 of flake scar length). The edge unit flakes exhibit somewhat smaller bulbs, proportionally, ranging mostly from minimal to moderate in size (1/8 to 3/8 of flake scar length). But just as pressure and percussion produce smaller bulbs also (e.g. very minimal and minimal: 20-22%), edge unit flakes are sometimes found to exhibit larger bulbs (e.g. substantial and very substantial: 30%).

The effect of increased force on the size of the bulb cannot be discussed in general terms. Increased force affects each behaviour in different ways when it comes to bulb size (see 'Size with increased force' data, above). Thus, there is no apparent connection between force level and bulb size.

(5) Distal shape (attribute #5.1 in Table 1)

			Force Level		
			min	mod	subst
press.:	:	thinning:	*IRR/RD/STR	STR/IRR	STR/IRR
		shaping:	IRR	STR/RD/IRR	
perc.:	cobble:	thinning:	IRR	IRR/RD/STR	RD/IRR
		shaping:	IRR/RD	IRR/RD	
	billet:	thinning:	IRR	IRR	RD
		shaping:	RD	RD	
edge units:	rub units and edge press on anvil:		RD(/STR)**		
		shearing:	RD(/STR)**	RD/IRR	
thinning:			IRR	IRR	IRR/RD(/STR)**
shaping:			IRR/RD	RD(/IRR)**	

(*: STR: straight; RD: rounded; IRR: irregular)
(**: (): less, but still well represented)

Straight distal edges are seen more often on pressure flakes than on percussion flakes, while rounded distal edges are seen more often on percussion and edge unit flakes. Irregular distal edges, however, are as frequent, and sometimes more frequent than either straight or rounded edges, except in percussion shaping with billet and in the minimal edge units where rounded edges are most common.

Irregular distal edges are most common on thinning flakes, while the shaping flakes exhibit similar proportions of rounded and irregular distal edges.

The preponderence of irregular edges tends to decrease with increased force in percussion flaking as the flake's distal edge becomes more regular, sometimes in a straight, but most often in a rounded manner. A similar situation occurs in pressure flaking. There, however, the trend is toward straighter, as opposed to more rounded, distal edges. It must be noted that irregular distal edges are still seen at moderate and substantial force levels in percussion and pressure flaking, although not generally as frequently as at the minimal force level. In shearing, where rounded distal edges are found in 44% of flake scars (straight: 27%; irregular : 29%), irregular edges become more frequent with increased force, while the percentage of straight edges decreases. The incidence of irregular edges decreases somewhat when shaping and thinning behaviours are used.

The correlation between the shape of the distal edge and the type of termination of the flake scar will be discussed in the next subsection (Subsection 2: Attribute associations).

(6) Termination (attribute #5.2 in Table 1)

			Force Level		
			min	mod	subst
press.:	:	thinning:	ST/F*	ST	ST
		shaping:	F	F	
perc.:	cobble:	thinning:	ST/F	F/ST	ST/F
		shaping:	F	F	
	billet:	thinning:	F	ST	F
		shaping:	F/ST	F	
edge units:		rub units and edge press on anvil:	ST		
		shearing:	F(/ST)**	F	
thinning:			F/ST	ST(/F)**	ST/F
shaping:			F	F	

(*: ST: step; F: feathered)
(**: (): less, but still well represented)

For the majority of cases, the shaping techniques result in flake scars displaying feathered terminations. Minimal percussion shaping with the billet does, however, create as many step terminations as feathered. In pressure, the contrast between thinning and shaping pressure flakes is rather dramatic: pressure shaping flakes usually feather out, while pressure thinning flakes display an abrupt step termination (with the exception of minimal pressure thinning, in which feathered terminations are as frequent as step terminations). Feathered terminations are also predominant in percussion shaping. The shearing units yield more feathered terminations than step, while the rub units and edge-press-on-anvil flakes end abruptly (step) 70% of the time.

The links between increased force and type of termination are associated with pressure thinning, and percussion shaping with the billet. In the former, an increase in force results in more abrupt (step) terminations. In percussion shaping with the antler billet, increased force yields more feathered flake scar terminations. The decrease in step terminations from minimal to moderate force in shearing is slight (5%). No overall generalizations about force increase and termination type were surmised.

Subsection 2: Attribute associations

Table II-33 provides an easy way of comparing different behaviours for each attribute. It also allows the comparison of attributes to see whether one attribute responds to certain technical variations in the same way another attribute responds to the same variations. These attribute associations lead to a better understanding of the morphological characteristics of flake scars. In order to show the patterns as clearly as possible, only attributes from the pressure and percussion behaviours were considered.

(1) Edge damage vs Morphology of proximal edge*

(attributes # 2.2 and 2.4 in Table 2)

(* morphology of proximal edge is used as an indicator of the extent of platform collapse)

Edge damage:

- ——————————————→ +
press. perc.
cob. bil.

Platform collapse:

+ ←—————————————— -
press perc.
cob. bil.

The incidence of edge damage appears to decrease with an increase in the extent of platform collapse. This result indicates the edge damage visible on each flake scar does not constitute the sum total of the damage created by the flaking action, but only what remains after a portion of the edge was removed through platform collapse. The presence of edge damage on a flake points to either very little platform collapse, or to damage so extensive that some of it still remained after a portion of the edge was removed.

(2) Edge damage vs Bulb distinctiveness (attributes #2.2 and 3.1 in Table 1)

Edge damage: $- \longrightarrow +- \longrightarrow +$

Bulb distinctiveness: $+- \longrightarrow + \longleftarrow +-/-$

The possibility of seeing a bulb increases along with that of seeing some edge damage, until the damage is at its greatest for each behaviour. When this happens, the frequency of bulb distinctiveness is reduced. As we noted previously (see Section 2, Subsection 1 (4) a) on bulb distinctiveness), the distinctiveness of the bulb of force increases with increased force. The above diagram, however, shows that extensively damaged edges reduce the possibility of seeing a bulb of force. In other words, the presence or absence of a bulb of force is affected by the extent of edge damage created by the flaking action.

(3) Shape of distal edge vs Flake scar termination

(attributes #3.1 and 4.1 in Table 1)

		Distal Edge		
		Straight	Rounded	Irregular
Termination	Feathered	40%*	73%	64%
	Step	60%	27%	36%

(*: Figures obtained from tabulation of all data in distal shape and termination from the Knife River flint experimental collection)

There is a distinct correlation between the shape of the flake's distal edge and the manner in which it terminates. The flakes ending in a straight edge exhibit a step termination 60% of the time. Forty percent of the time, they feather out. This means a 3:2 ratio of step to feathered terminations for flakes with a straight distal edge.

A rounded distal edge is more likely to be feathered as this type of termination outweighs the step termination four to one in flakes with rounded distal edges.

Flake scars with an irregular distal edge also show a preponderence of feathered terminations. The ratios, however, are not as high as for the rounded distal edges (approximately two feathered to one step termination).

Subsection 3: Attribute analysis vs Information from videotape

The manufacturing of the Knife River flint experimental tools was videotaped in order to have a permanent record of the variables involved in the removal of each flake. These variables were drawn from Young and Bonnichsen (1984: 161-177). A careful study of the videotape provided the information listed in Table II-34. The tape is stored in with the Project for the Study of Material Culture, Department of Anthropology, University of Alberta, Edmonton, Alberta.

The information obtained from the videotape is used here in conjunction with the data from the attribute analysis in an attempt to compare and contrast specific groups of behaviours.

(1) Percussion vs Pressure; Thinning vs Shaping

a) Platform preparation (see Tables II-34 and II-35)

A slightly greater percentage of experimental artifacts representing pressure behaviours, than of experimental artifacts representing percussion behaviours, underwent some form of edge preparation. The percentages are separated only by 19%, however, and the sample is small (e.g. only six pressure behaviours).

One observation, however, appears undeniable: the thinning behaviours require platform preparation 50% of the time, while the shaping behaviours do not. The only types of platform preparation performed were designed to thicken the platform edge in order to avoid platform collapse and to remove irregularities in order to achieve better control of the shape and size of the thinning flake about to be removed. The following statements explain why platform preparation was performed almost exclusively on thinning flakes:

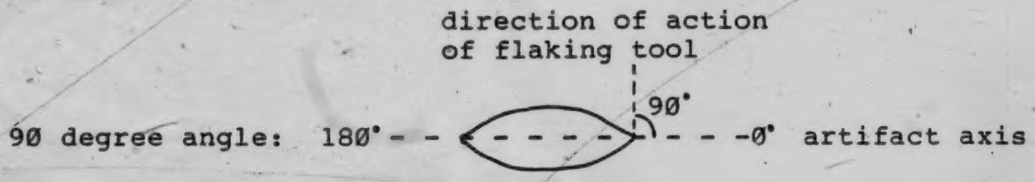
1) while platform collapse is avoided as much as possible in the thinning units, it is expected and sought in the shaping flakes;

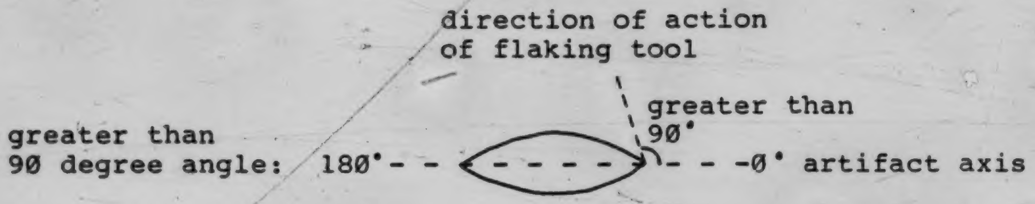
2) the shape and length of a flake is much more important in thinning than in shaping which simply has to remove some of the artifact's margin. The irregularities which would reduce control over the shape and size of the flake are therefore removed before a thinning flake is struck.

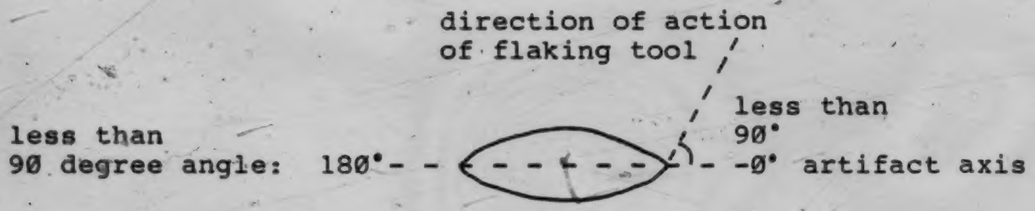
It should be noted that platform preparation is restricted to specific small areas of the edge and not to the entire edge.

b) Angle (see Tables II-34 and II-36)

The angle referred to in this section is that created by the flaking tool and the axis of the artifact (after Young and Bonnichsen, 1984: 165-179). This angle is potentially important, as it determines the direction of the force waves imparted to the artifact by the flaking tool, and the action taken by that tool.

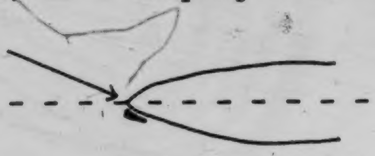

direction of action of flaking tool
90°
90 degree angle:
180°
0°
artifact axis


direction of action of flaking tool
greater than 90°
greater than 90 degree angle:
180°
0°
artifact axis

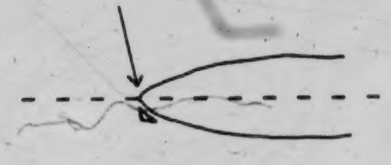

direction of action of flaking tool
less than 90°
less than 90 degree angle:
180°
0°
artifact axis

There are significant differences between specific sets of behaviours, in the angle created by the horizontal axis of the artifact, and the direction of the blow or pressure applied by the flaking tool.

In thinning, the force is directed inwards, towards the centre of the artifact, in order to remove a long, thin flake. In shaping, the force is directed downwards so as to restrict the removal of material to the immediate margin area, as a shaping flake should do.



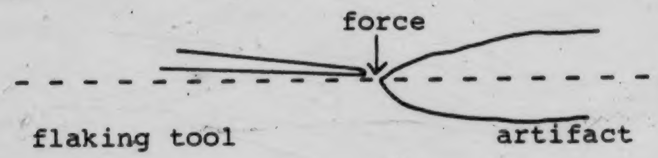
thinning



shaping

This is reflected by the data obtained on the angle of tool to artifact: the thinning behaviours generally yield lower angle values than the shaping behaviours (shaping: 88% with 67.6 to 89 degree angles; thinning: 48% with 67.6 to 89 degree angles and 36% with 46 to 67.5 degree angles) (N.B.: actual angles are not measured, but rather, estimated) .

In pressure shaping (9i, 9ii) and indirect percussion thin (16i, 16ii) the angle created by the flaking tool and flaked artifact does not directly reflect the direction of the force being imparted to the stone. The videotape of the flaking experiments revealed that, although the flaking tool meets the horizontal plane of the artifact at ~~an~~ angle of less than 45 degrees, the force is being applied mostly downwards. Thus although the tool-artifact angle has a low value, the actual value for the angle of incidence, or the direction of the force, is much higher, probably between 67.6 and 89 degrees. The figures between brackets in Table II-36 take that fact into account.



The percussion and pressure behaviours are also differentiated by their angles of force incidence. In percussion, 14% of behaviours make use of 90 degree angles, 68% make use of 67.6 to 89 degree angles, and 18% of 46 to 67.5 degree angles. In pressure, no 90 degree angles were found, and the remaining three angle categories (67.6-89 degrees, 46-67.5 degrees, 0-45 degrees) share equal numbers of behaviours (see Table II-37).

In summary, thinning behaviours involve angles of force incidence that are more acute than those found in shaping. The difference stems from the shape of the flake the craftsman intends to remove: more acute angles result in force directed inwards towards the artifact and removing long, thin flakes; while the wider angles cause the imparted force to take a downward direction, thus removing thicker, shorter flakes.

Regardless of whether the artifact is being shaped or thinned, the angle of force incidence into the stone decreases from percussion to pressure.

c) Support system (see Tables II-34 and II-38)

This variable refers to the manner in which the flintknapper holds the artifact. This position, in turn, determines the strength with which the artifact is being supported while flaking takes place.

Type	Description	Strength
2	Artifact held with leather pad between knees; punch tool resting on artifact and held in left hand; percussion tool held in right hand (indirect percussion)	1- very strong
4	Artifact resting on pad placed on lap; held on top by entire hand	1- very strong
1	Artifact held down against palm with three fingers (palm covered by leather pad); hand resting on lap	2- strong
3	Artifact held horizontally between thumb and fingers; hand resting on lap	2- strong

(after Young and Bonnichsen, 1984: 165-166)
(see also my Table II-34)

A strong type of support system is used in the majority of cases for percussion and pressure behaviours. In percussion flaking, a very strong support system is required only for the indirect percussion technique (behaviours 16i and 16ii) and for substantial percussion thinning with the billet (behaviour #11). Substantial percussion thinning with the cobble (behaviour #14), on the other hand, does not require the assistance of a very strong support system. In pressure flaking, only a strong type of support system is used.

Although both methods rely mainly on a strong support system, the type of system itself varies. All percussion behaviours making use of a strong support system involve type #3: artifact held horizontally between thumb and fingers, hand resting on lap. On the other hand, all pressure behaviours involve the type #1 system in which the artifact is held down against the palm (the palm is covered by a leather pad) while the hand rests on the flintknapper's lap. Thus, despite the fact that percussion and pressure behaviours, for the most part, require a strong support system, the actual type of system used by each differs.

When comparing the thinning and shaping behaviours, Table II-38 reveals that all of the shaping behaviours and two-thirds of the thinning behaviours make use of a strong support system. As seen earlier, the only thinning techniques requiring a strong support system are indirect percussion thinning (behaviours #16i and 16ii) and substantial percussion thinning with the billet (behaviour #11). Thinning and shaping behaviours are not distinguished by the type of support system used as are the percussion and pressure behaviours. Within the 'strong' group of support system types, type #3 is used in 62% of the thinning behaviours (or 42% if strong and very strong support system types used), as well as in 67% of the shaping behaviours. The removal of thinning and shaping flakes does not appear to require very different artifact support systems. Were it not for the indirect percussion thinning behaviours, in fact, all but one of the thinning behaviours would require a support system of the same strength as that used in shaping (i.e. 'strong'), and the percentages for each type of system used in thinning and shaping would be remarkably similar (11% vs 0% for type #4; 33% vs 33% for type #1; and 56% vs 67% for type #3).

d) Failed scars (see Tables II-34 and II-39)

Three types of failure were recorded:

A) platform crushing: the platform area simply crumbles and the craftsman fails to remove a flake scar of the desired type.

B) many tries: the flintknapper is unable to remove the desired type of flake on first attempt and goes over the same area repeatedly until he is successful.

C) wrong force: the flintknapper uses a force level greater than that required of him (e.g. using substantial force on the experimental tool reserved for moderate pressure thin (7ii)).

The percussion behaviours display a high percentage of multiple attempts at removing a flake ("many tries") and a higher percentage of platform crushing than seen in the pressure behaviours. Almost three-quarters (69%) of the percussion behaviours saw repeated blows before a successful flake was removed, and one third (29%) of the flake scars eventually created were failures (crushed platform).

Pressure flaking does not exhibit the same high rate of failure. Two-thirds of the behaviours required very few tries before the removal of a successful flake, and only 8% of the flake scars were failures, as opposed to 29% in percussion.

The fact the flintknapper had to hit the artifact so many times before a successful flake came off probably explains why more unsuccessful flakes were recorded on the experimental tools flaked by percussion than on those flaked by pressure. This may also have some effect on the percentages of edge damage found in percussion. This question will be explored further in a later section.

The use of the wrong force level when removing a flake does not appear to be a major problem in the Knife River flint experimental collection. On each of the behaviours where it is observed, the use of the wrong force is represented by only one or two flakes. Since the average number of flakes per behaviour is 14, the percentage of flakes produced by the wrong force can be expected to be approximately:

2 to 4% in percussion flaking
1 to 2% in pressure flaking
1 to 2% in the thinning behaviours
2 to 5% in the shaping behaviours

As can be seen, the percentages are all quite low and similar for pressure vs percussion and thinning vs shaping.

(2) Percussion: Billet vs Cobble

(direct percussion only)

a) Platform preparation (see Tables II-34 and II-40)

Not many of the percussion behaviours required some platform preparation (30%). Only one of the five edges representing percussion behaviours with billet and two of the five edges representing percussion behaviours with cobble underwent rub-abrading or rub-buffeting in a specific area of the edge in order to prepare it before certain flakes were struck off.

b) Angle (see Tables II-34 and II-41, and description of angles in Section 2, Subsection 3 (1), above)

The angle between percussor and artifact appears to be wider with the billet (four of five behaviours using an angle of between 67.6 and 89 degrees, one behaviour using approximately a 90 degree angle of incidence) than with the cobble (17% of behaviours using a 90 degree angle, 37% using a 67.6 to 89 degree angle, and 47% using a 46 to 67.5 degree angle). This difference in tool position accounts for differences in the direction of the force waves each tool imparts to the artifact, which in turn must account for different morphological features of flake scars produced with the use of the billet or the cobble.

c) Support system (see Tables II-34 and II-42, and description of support system types and strength in Section 2, Subsection 3 (1), above)

Other than confirming the fact that percussion techniques require mainly a 'strong' support system of type #3, Table II-42 also shows this applies to the majority of percussion behaviours, regardless of the tool used (one exception: substantial percussion thin with billet).

d) Failed scars (see Tables II-34 and II-43, and description of variables in Section 2, Subsection 3 (1), above)

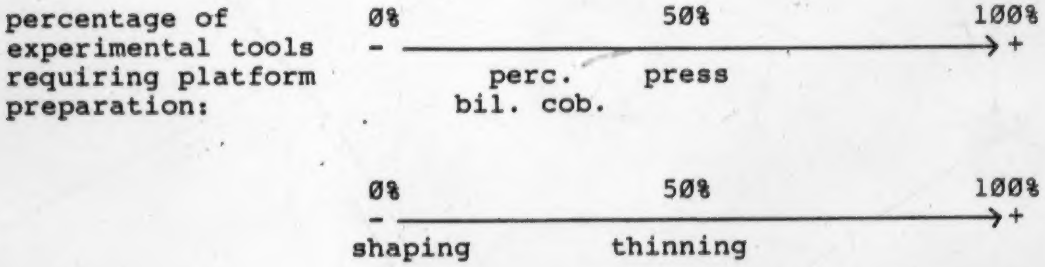
Percussion flaking with the use of the cobble requires more blows to a specific area than does the billet in order to remove a successful flake. Probably as a result of this difference, many more flakes struck off with the cobble than with the billet exhibit platform crushing, and fail to remove the expected amount of material. A link between these observations and frequencies of edge damage for billet and cobble percussion will be sought in Subsection 3 (4), below.

As seen earlier, data contamination due to the use of the wrong force in removing certain flake scars is quite negligible.

(3) Videotape information - Summary

This section is a summary of all the information outlined in the previous two sections on the data obtained from the videotaping of the production process of the Knife River flint experimental collection.

a) Platform preparation


percentage of experimental tools requiring platform preparation:
0%
50%
100%
-
+
perc.
bil. cob.
press
0%
50%
100%
-
+
shaping
thinning

Platform preparation appears to be performed slightly more often for pressure than for percussion flaking, and somewhat more when using the cobblw than when using the billet in percussion flaking. This information applies to the thinning behaviours only, since the shaping behaviours from the Knife River flint collection did not yield any examples of platform preparation before the removal of flakes. Thus, to summarize, the sets of behaviours from the experimental collection requiring some form of platform preparation are, in descending order: 1) pressure thinning, 2) percussion thinning with cobble, and 3) percussion thinning with billet.

b) Angle

angle width: - ——————→ +   - ——————→ +
press.   cob.   bil.   thin   shape

The angle created by the flaking tool's direction and the horizontal axis of the flaked artifact (see Section 2, Subsection 3 (1), above) shows a general increase in size from the pressure, to the percussion with cobble, to the percussion with billet behaviours.

The relationship between acuteness of angle and thinning or shaping flakes is based on the fact that a force entering the artifact at a smaller angle will remove long, thin flakes, while a force entering the same artifact at a wider angle will remove a shorter, thicker flake, that is to say, a shaping flake.

c) Support system: type and strength

The most common types of support systems used to hold the artifact while it is being flaked offer strong support to the artifacts. Only a few behaviours made use of a very strong type of support system. Although the pressure and percussion behaviours rely on systems offering a similar amount of support, the actual type of support system varies from percussion to pressure. In percussion flaking, regardless of the type of percussor used, the artifact is held horizontally between thumb and fingers while the craftsman's hand rests on his lap. In pressure flaking, the artifact is held against a leather pad, covering the palm, by three fingers while the craftsman's hand rests on his lap. Both types of support systems are associated equally often with the thinning and shaping behaviours.

d) Failed scars

platform crushing:	- ———→ + press/bil. cob	- ——→ + sh. th.
many tries:	- ———→ + press. bil. cob.	- ——→ + sh. th.

The number of failed attempts (e.g. actual unsuccessful blows in the case of percussion flaking) at removing a satisfactory flake, as well as the number of flake scars with crushed platforms, increases from pressure to percussion with billet, to percussion with the cobble; and from shaping to thinning. Percussion thinning with the cobble is therefore the most likely to produce failed scars, while pressure shaping appears to be the most effective method of removing the greatest number of successful flakes.

The use of the wrong level of force occurred less than 5% of the time in the Knife River flint experimental collection, and is therefore not expected to have erroneously influenced the statistics related to each behaviour.

(4) Summary of videotape information vs summary of attribute analysis information

Some of the information retained by videotaping the production of the Knife River flint experimental collection proved very useful with regards to explaining some of the morphological detail found on the flake scars from that collection.

a) Failed scars (many tries) vs edge damage and extent of platform collapse (morphology of proximal edge)

It has already been established that percussion flaking requires more attempts than pressure flaking before a successful flake is struck off. Edge damage is also observed more often on flake scars created by a percussion behaviour than on those resulting from pressure flaking. It is therefore assumed that the frequency with which proximal edge damage is seen on flake scars is determined, in part, by the number of times the flintknapper must hit or apply pressure to a particular area in order to remove the desired type of flake.

There is one problem with this assumption, however: percussion with the antler billet results in more visible edge damage than percussion with the cobble, yet it is percussion with the cobble that requires more blows before a desirable flake is produced. The answer may lie with the information from another attribute, namely the morphology of the proximal edge. As discussed earlier, the values for this attribute reflect the amount of material removed from the flake scar through platform collapse. Percussion with the cobble results in a greater amount of platform collapse (51% of flake scars show a straight edge, 30% show flat curves) than does percussion with the billet (37% straight edges, 50% flat curves). It is possible that by removing more of the platform area, percussion with the cobble also removes a large portion of the damaged area, thus leaving fewer cobble percussion flakes with damaged proximal edges, which would lead us to think the billet causes more damage than the cobble. Of course, the number of attempts at removing a flake may not be the only determinant of the amount of edge damage caused to the flake scar.

b) Contact with other substance vs distal edge shape

The thin coat of paint applied to the preforms for contrast before one of the experimental behaviours was performed on them, constitutes a second type of material which must be crossed by the force waves before a flake can be detached. As insignificant as it may look, the layer of paint offers a different type of resistance to the force waves, partly because of its more elastic properties. This is not part of the information drawn from the videotape but it is an input variable that may have some effect on the outcome of the flake and, as such, should be considered.

In an earlier study on stone tools, Bonnichsen notes in a section on fracture morphology:

> When the distal ends of flakes are jagged and irregular..., it is a good indication they were in contact with another substance when the flake was detached. (1977: 132, 135)

This statement implies the thin coat of white paint applied to the experimental artifacts may be to blame for the high incidence of irregular distal edges found in the Knife River flint experimental collection. This type of distal edge is found in 35% of all flake scars, while rounded distal edges account for 39% of the flake scars, and straight distal edges for 26%.

There is also a general trend towards less irregularity of the distal edge with application of greater force (see Table II-44). Without disappearing completely, the ratio of irregular distal edges to rounded and straight distal edges dwindles as the force is increased from minimal to moderate to substantial. Larger amounts of force thus appear to create cleaner, more regular distal edges, either rounded or straight.

TABLE II-1

PERCUSSION THIN - BILLET

		Minimal	Moderate	Substantial
Edge damage		extensive	extensive	very extensive
Ribs:	presence	mod-ext	moderate	very extensive
	distinctiveness	(indist-mod	variable	variable)
Edge morphology		var (2 str, 1 conv. proj, 1 other)	straight	flat curve
Bulb:	presence	(variable	not vis.	var.)
	size	X	X	X

TABLE II-2

PERCUSSION THIN - HAMMERSTONE

		Minimal	Moderate	Substantial
Edge damage		moderate	moderate	very extensive
Ribs:	presence	extensive	moderate	very extensive
	distinctiveness			
Edge morphology		straight	flat curve	flat curve
Bulb:	presence	variable	visible	visible
	size	(var.	var.	var.)

TABLE II-3

PRESSURE THIN

		Minimal	Moderate	Substantial
Edge damage		limited	mod-ext.	lim.-mod.
Ribs:	presence	rare-limited	mod-ext.	extensive
	distinctiveness	indist.	indist.	indist.
Edge morphology		½ fl. curve/ ½ straight	flat curve	U-shaped notch
Bulb:	presence	not visible	variable	visible
	size	X	mod-subst.	mod to subst.

TABLE II-4

PERCUSSION SHAPE - BILLET

		Minimal	Moderate
Edge damage		extensive	very extensive
Ribs:	presence	limited	moderate
	distinctiveness	pronounced	indistinct
Edge morphology		straight	straight
Bulb:	presence	not visible	variable
	size	X	variable

TABLE II-5

PERCUSSION SHAPE - HAMMERSTONE

		Minimal	Moderate
Edge damage		extensive	moderate
Ribs:	presence	limited	very extensive
	distinctiveness	variable	indistinct
Edge morphology		straight	½ straight - ½ flat curve
Bulb:	presence	variable	variable
	size	subst.-very subst.	v. min - mod.

TABLE II-6

PRESSURE SHAPE

		Minimal	Moderate
Edge damage		moderate	moderate
Ribs:	presence	limited	extensive
	distinctiveness	indistinct	variable
Edge morphology		½ str. - ½ flat curve	flat curve
Bulb:	presence	not visible	variable
	size	X	v. min - mod.

TABLE II-7

SHEAR THIN - PRESSURE FLAKER

		Minimal	Moderate
Edge damage		limited	limited
Ribs:	presence	moderate	moderate
	distinctiveness	variable	indistinct
Edge morphology		straight	straight
Bulb:	presence	not visible	not visible
	size	X	X

TABLE II-8

SHEAR THIN - COBBLE

		Minimal	Moderate
Edge damage		extensive	extensive
Ribs:	presence	moderate	extensive
	distinctiveness	indistinct	indistinct
Edge morphology		straight	½ straight - ½ flat curve
Bulb:	presence	not visible	not visible
	size	X	X

TABLE II-9

SHEAR SHAPE - PRESSURE FLAKER

		Minimal	Moderate
Edge damage		absent-rare	moderate
Ribs:	presence	moderate	extensive
	distinctiveness	mod-pron.	indistinct
Edge morphology		straight	½ flat curve - ½ straight
Bulb:	presence	not visible	variable
	size	X	very minimal - moderate

TABLE II-10

SHEAR SHAPE - COBBLE

		Minimal	Moderate
Edge damage		extensive	extensive
Ribs:	presence	extensive	very extensive
	distinctiveness	indistinct	variable
Edge morphology		straight	straight
Bulb:	presence	not visible	visible
	size	X	v. min - mod.

TABLE II-11

RUB BUFFET WITH:

		Billet	Cobble
Edge damage		moderate	moderate
Ribs:	presence	moderate	absent-rare
	distinctiveness	indist-var.	X
Edge morphology		straight	straight
Bulb:	presence	not visible	not visible
	size	X	X

TABLE II-12

RUB ABRADE WITH COBBLE AND PRESSURE RUB WITH PRESSURE FLAKER

		Rub Abrade	Pressure Rub
Edge damage		absent-rare	moderate
Ribs:	presence	absent-rare	moderate
	distinctiveness	X	indist-mod.
Edge morphology		straight	straight
Bulb:	presence	not visible	not visible
	size	X	X

TABLE II-13: COMPARISONS: THINNING VS SHAPING VS EDGE UNITS

THINNING	SHAPING	EDGE UNITS
EDGE DAMAGE:		
mostly mod.*, some lim. - ——→ + press. perc. -perc: damage increases with force -press: damage greatest at mod. force	mod. or more - ——→ + press. perc. -perc: -billet: incr. with force -cobble: decr. with force -press: unaffected by force	abs/rare: 17% limited: 17% moderate: 33% extensive: 33%
RIBS PRESENCE:		
-perc: least at mod. force -press: increases with force - ——→ + press. perc. -mod.-very ext.: 88%	-incr. with force -press. = same as for perc. -lim.: 50% ; mod.: 17% ext.: 17% ; v.ext: 17%	83% mod. or more (except: rub buffet & rub abrade with cobble)
RIBS DISTINCTIVENESS:		
-no pattern	-perc: incr. with force -press: decreases with force	ind: 60% ; var: 25% mod: 15% ; pron: 10%
PROXIMAL EDGE MORPHOLOGY (Platform Collapse**):		
- ——→ + perc. press. -incr. with force -evident at lower force level with press (min) than perc (cobble: mod) (billet: subst.) -mod: 44% ; abs: 22% ; min: 11% ; ext: 11% ; var: 11%	- ——→ + perc. press. - ——→ + bill. cobb. -evident at lower force level with press. (min) than perc (cobble: mod) (billet: no apparent collapse) -abs: 50% ; min: 33%; mod: 17%	mostly no collapse (except for a bit in: mod. shear thin with cobble; moderate shear shape with pressure flaker) -abs: 83% ; min: 17%
BULB PRESENCE:		
-no pattern	-bit more frequent with cobble than with billet or press.	-rarely visible (except with mod. shear shape) -not vis.: 83%

Cont'd

TABLE II-13, Cont'd

THINNING	SHAPING	EDGE UNITS
BULB SIZE (length):		
-no pattern	-larger bulb only with percussion shape	-small

For thinning and shaping:
-edge damage decreases as platform collapse increases
-edge damage decreases, and platform collapse increases from percussion with billet, to percussion with cobble, to pressure flaking:

	platform collapse	edge damage
	+	−
pressure	↑	
percussion: cobble		
billet		↓
	−	+

*See Table 1 for abbreviated terms

** Platform collapse:
- none: if edge is STRAIGHT
- minimal: if edge is ½ STRAIGHT/½ FLAT CURVE
- moderate: if edge is FLAT CURVE
- substantial: if edge is U-SHAPED NOTCH

TABLE II-14: COMPARISONS: PRESSURE VS PERCUSSION

PRESSURE	PERCUSSION
EDGE DAMAGE:	
-less -thin: damage greatest at mod. force -shape: damage not affected by force	-more -thin: increases with force -shape: -billet: incr. with force -cobble: decr. with force
RIBS PRESENCE:	
-thin: less than perc. thin -shape: same as perc. shape -incr. with force (thin and shape)	-thin: more than press. thin -shape: same as press. shape -thin: least at mod. force -shape: incr. with force
PLATFORM COLLAPSE * (Proximal Edge Morphology):	
-more than percussion -evident at lower force level (min.)	-less than pressure -evident at mod. or subst. force only (when present)
BULB PRESENCE:	
-less frequent	-slightly more frequent (most frequent with cobble)
BULB SIZE (length):	
-similar to percussion -very min/min.**: 20% subst./very subst.: 52%	-similar to pressure -(see pressure percentages)

* Platform Collapse:
-none: if edge is STRAIGHT
-minimal: if edge is STRAIGHT/FLAT CURVE
-moderate: if edge is FLAT CURVE
-substantial: if edge is U-SHAPED NOTCH

** See Table 1 regarding abbreviated terms

TABLE II-15: COMPARISONS: BILLET VS COBBLE (HAMMERSTONE)

BILLET	COBBLE
EDGE DAMAGE:	
-more: ext.: 60%, v. ext: 40% * -shaping: damage increases with force	-less: mod: 60%, ext: 20%, v. ext: 20% -damage decreases with force
RIBS PRESENCE:	
-slightly less prevalent	-slightly more prevalent
PLATFORM COLLAPSE ** (Proximal edge morphology):	
-slightly less	-slightly more
BULB PRESENCE:	
-less frequent	-more frequent

* See Table 1 regarding abbreviated terms

** Platform Collapse:
- none: if edge is STRAIGHT
- minimal : if edge is STRAIGHT/FLAT CURVE
- moderate: if edge is FLAT CURVE
- substantial: if edge is U-SHAPED NOTCH

TABLE II-16: COMPARISONS BETWEEN MINIMAL UNITS

MINIMAL PERCUSSION (4 behaviour units)	MINIMAL PRESSURE (2 behaviour units)	EDGE UNITS (12 behaviour units)
EDGE DAMAGE:		
-ext*: 3 ; mod.: 1	-rare/lim.: 1 ; mod.: 1	-abs./rare: 17% ; lim.: 17% ; mod.: 33% ext.: 33%
RIBS PRESENCE:		
-lim.: 2 ; mod-ext: 1 ; ext.: 1	-rare-lim.: 1 lim.: 1	-abs./rare: 17% ; mod.: 50% ; ext: 25%; very ext.: 8%
RIBS DISTINCTIVENESS:		
-ind-mod: 1; mod.: 1; pron.: 1; var.: 1	-indistinct: 2	-ind.: 60%; mod: 15%; pron.: 10%; var: 25%
PLATFORM COLLAPSE ** (Proximal Edge Morphology):		
-none: 3 ; var.: 1	-min.: 1 ; mod.: 1	-none: 83%; min: 17%
BULB PRESENCE:		
-var.: 3 ; not vis.: 1	-not visible: 2	-not vis.: 83%; visible: 8%; variable: 8%
BULB SIZE (length):		
-sub-very sub: 1 var.: 1	X	-very minimal when seen

* See Table 1 regarding abbreviated terms

** Platform Collapse:
-none: if edge is STRAIGHT
-minimal: if edge is STRAIGHT/FLAT CURVE
-moderate: if edge is FLAT CURVE
-substantial: if edge is U-SHAPED NOTCH

TABLE II-17: STRONG CORRELATIONS

Behaviour	#of attribute states shared ..... (out of 14)	with: # of other behaviours (out of 30) (total: 31 behaviours)
(2ii): pressure rub with pressure flaker	9 - 10½	17
(4i) : moderate shear thin with pressure flaker	9 - 12	13
(9i) : minimal pressure shape	9 - 11	13
(50) : edge press on anvil	9 - 11	13
(3i) : min. shear thin with pressure flaker	9 - 12	11
(3ii): min. shear thin with cobble	9 - 11	11

TABLE 11-10: CORRELATIONS, ALL BEHAVIOURS

	11	111	21	211	31	311	41	411	51	511	61	611	71	711	8	91	911	101	1011	11	121	1211	131	1311	14	151	1511	161	1611	201	50	
11	X	10½	8½	9	9	9	9	8	8	10	7½	8½	8	6½	3	8½	6	5	3	5	7½	7½	6	5½	3	6½	7½	5	3½	7	8	11
111		X	10½	10	9	7½	8	7	7½	8	7½	7	8½	4	2½	9	6½	5½	3	5	8½	7	7	6	2½	7	7	5	3	6	7½	111
21			X	10½	9½	9½	9½	8	8½	8	8	7½	8	5½	3½	9½	7½	6	5½	5	8	8	8	8½	3	6	9	6	4½	6½	10	21
211				X	9	9½	10½	9	9	9	10	6½	8½	6½	4	11	9	8	6	7½	9½	9½	8½	9½	4½	8½	9	7½	5	8½	11	211
31					X	10	12	8	10½	9	8½	7	8½	5	3½	9½	6½	8	5½	7½	8½	9½	7	7	3	7½	6½	6	5	8	9	31
311						X	11	10½	9½	9½	7½	7½	8½	7	4½	8½	6	7½	7	4½	9	9½	7	7½	3½	7	7	7	6½	7	10½	311
41							X	9	10½	9½	8½	7½	10	6½	4½	9½	8	7½	6	5½	7½	9	7	7½	3	6½	7	6½	5½	9½	10½	41
411								X	8	9	9	6½	9½	8½	7½	9½	8	7½	8	5½	9½	8	7½	6½	4½	8½	7½	7	6	8	10	411
51									X	7	7	5½	9	6½	4½	8	7	7	7	4½	7	7½	6½	6½	3	5½	4½	5½	5½	6½	9½	51
511										X	8	9	6½	4½	2½	7	6½	7	3½	5	8	8½	6½	5	1½	6½	6	6½	4½	5½	7	511
61											X	8½	8	7½	6½	11	10½	8½	6½	8½	7½	10	10	9½	4½	8	9½	8	6	7½	[illegible]	61
611												X	5½	5	3½	7	7½	6½	5	7	6½	9	8	7	4½	7½	8	9½	6½	6	7	611
71													X	7	6	9½	8	5½	6½	5	10	6½	6	6½	4	7	6½	5½	5½	9	10	71
711														X	10	6½	9	8	9	5	5	7	7½	9	5½	5½	8	8	6	7½	8½	711
8															X	5	7½	5½	8½	5½	3	5	6½	6½	5½	4	7	6	5	5½	5½	8
91																X	8½	8½	6½	7	9½	8	8½	8	3½	9	9	6½	5	9½	10	91
911																	X	7	6½	7	6	7½	9	9	6	6½	8½	8	5½	8	8½	911
101																		X	8½	7	6½	9½	8½	8	4½	9	7½	8½	7½	7	7	101
1011																			X	6½	6	7½	6½	7	6	6½	5½	7	7	6½	7½	1011
11																				X	6	8½	6½	7½	9	6½	8½	8½	6½	6½	5½	11
121																					X	8	6½	7	4½	10	6½	7½	6	6½	9	121
1211																						X	8½	8½	4	8½	9	8	6	7	6½	1211
131																							X	10	5½	7½	9	9½	6	7	7½	131
1311																								X	7½	7½	9	11	6½	7	9	1311
14																									X	5	7	8	8	6½	4½	14
151																										X	7½	8½	6½	6	7	151
1511																											X	8½	6½	8½	7½	1511
161																												X	8	7½	7½	161
1611																													X	6½	6½	1611
201																														X	9	201
50																															X	50

CORRELATIONS:

0	NONE	(None)
1 to 2½	VERY WEAK	(4)
3 to 5½	WEAK	(88)
6 to 8½	MODERATE	(273)
9 to 11½	STRONG	(99)
12 to 13½	VERY STRONG	(1)
14	SAME	(0)

TABLE II-19: WEAK CORRELATIONS

Behaviour	# of attribute states shared .... (out of 14)	with: # of other behaviours (out of 30) (total 31: behaviours)
(14) : substantial percussion thin with cobble	3 - 5	20
(8) : substantial pressure thin	3 - 5	18
(11) : substantial percussion thin with billet	3 - 5	12
(16ii): substantial indirect percussion thin	3 - 5	12
(7ii) : moderate pressure thin	3 - 5	10

TABLE II-20: CORRELATIONS FOR EDGE-PRESS-ON-ANVIL

# Of Attributes Shared	Pressure Units	Edge Units
11		(2ii) pressure rub with pressure flaker
10½		(3ii) minimal shear thin with cobble
		(4i) moderate shear thin with pressure flaker
10	(7i) minimal pressure thin	(2i) rub buffet with billet
	(9i) minimal pressure shape	(4ii) moderate shear thin with cobble
9½		(5i) minimal shear shape with pressure flaker
9	(20i) re-sharpening: pressure over pressure see	(3i) minimal shear thin with pressure flaker
		(6i) moderate shear shape with pressure flaker

TABLE II-21: CORRELATIONS FOR RE-SHARPENING BEHAVIOUR (PRESSURE OVER PRESSURE)

# of Attributes Shared		Pressure Units		Percussion Units
9½	(9i)	minimal pressure shape	(4i)	moderate shear thin with pressure flaker
	(7i)	minimal pressure thin	(50)	edge press on anvil

TABLE II-22: CORRELATIONS FOR MODERATE INDIRECT PERCUSSION THINNING

# OF Attributes Shared	Pressure Units	Percussion Units
11	(strong correlations)	(13ii) moderate percussion thin with cobble
9½		(13i) minimal percussion thin with cobble
8½	(moderate correlations)	(10i) minimal percussion thin with billet (11) substantial percussion thin with billet (15i) minimal percussion shape with cobble (15ii) moderate percussion shape with cobble
8	(7ii) moderate pressure thin (9ii) moderate pressure shape	(12ii) moderate percussion shape with billet (14) substantial percussion thin with cobble
	(16ii) substantial indirect percussion thin	
7½	(20i) re-sharpening: pressure over pressure	(12i) minimal percussion shape with billet
7		(10ii) moderate percussion thin with billet
6½	(9i) minimal pressure shape	
6	(8) substantial pressure thin	

TABLE II-23: CORRELATIONS FOR SUBSTANTIAL INDIRECT PERCUSSION THINNING

# Of Attributes Shared	Pressure Units	Percussion Units
8		(14) substantial percussion thin with cobble
	(16ii) moderate indirect percussion thin	
7½		(10i) minimal percussion thin with billet
7		(10ii) moderate percussion thin with billet
6½	(2~~0i~~) re-sharpening: pressure over pressure	(11) substantial percussion thin with billet
		(13ii) moderate percussion thin with cobble
		(15i) minimal percussion shape with cobble
6	(7ii) moderate pressure thin	(15ii) moderate percussion shape with cobble
		(12i) minimal percussion shape with billet
		(12ii) moderate percussion shape with billet
		(13i) minimal percussion thin with cobble

TABLE II-24: CORRELATIONS: EDGE UNITS VS PRESSURE VS PERCUSSION BEHAVIOURS

# Of Attributes Shared	Behaviours		
	Pressure	Percussion	Edge Units
11	(9i)min. press. shape*		(2ii)press. rub w. pr. fl. (6i)mod. shear shape w. pr. fl.
10½	(9ii)mod. press. shape		(6i)mod. shear shape w. pr. fl.
10	(7i)min. press. thin.		(4i)mod. shear thin. w. pr. fl. (50)edge press on anvil
	(9i)min. press. shape		(50)edge press on anvil
		(12ii)mod. perc. shape w. billet	(6i)mod. shear shape w. pr. fl.
		(13i)min. perc. thin. w. cobble	(6i)mod. shear shape w. pr. fl.
9½	(7i)min. press. thin.		(4ii)mod. shear thin. w. cobble
	(9i)min. press. shape		(2i)rub buffet w. bill. (3i)min. shear thin. w. pr. fl. (4i)mod. shear thin. w. pr. fl. (4ii)mod. shear thin. w. cobble
	(20i)re-sharpening: press. over press.		(4i)mod. shear thin. w. pr. fl.
		(12i)min. perc. shape w. billet	(2ii)press. rub w. pr. fl. (4ii)mod. shear thin. w. cobble
		(12ii)mod. perc. shape w. billet	(2ii)press. rub w. pr. fl. (3i)min. shear thin. w. pr. fl. (3ii)min. shear thin. w. cobble
		(15ii)mod. perc. shape w. cobble	(6i)mod. shear shape w. pr. fl.
		(13ii)mod. perc. thin. w. cobble	(2ii)press. rub w. pr. fl. (6i)mod. shear shape w. pr. fl.
		(16i)mod. indir. perc. thin.	(6ii)mod. shear shape w. cobble

Cont'd

TABLE II-24, Cont'd

# Of Attributes Shared	Behaviours		
	Pressure	Percussion	Edge Units
9	(7i)min. press. thin.		(5i)min. shear shape w. pr. fl.
	(9i)min. press. shape	———	(1ii)press. rub w. pr. fl.
	"	(15ii)mod. perc. shape w. cobble	
	(9ii)mod. press. shape		(2ii)press. rub w. pr. fl.
	(20i)re-sharpening: press. over press.		(50)edge press on anvil
—		(13ii)mod. perc. thin. w. cobble	(50)edge press on anvil
		(12i)min. perc. shape w. billet	(3ii)min. shear thin. w. cobble
			(50)edge press on anvil
		(12ii)mod. perc. shape w. billet	(4i)mod. shear thin. w. pr. fl.
			(6ii)mod. shear shape w. cobble
		(15ii)mod. perc. shape w. cobble	(2i)rub buffet w. bill. (2ii)press. rub w. pr. fl.

* **List of abbreviations:**

-min.: minimal
-mod.: moderate
-press.: pressure
-perc.: percussion
-thin.: thinning
-w.: with
-pr. fl.: pressure flaker
-bill.: billet

TABLE II-25: CORRELATIONS: PERCUSSION VS PRESSURE

# Of Attributes Shared	Pressure Units	Percussion Units
10	(7i) minimal pressure thin	(12i) minimal percussion shape with billet
9½	(9i) minimal pressure shape	(12i) minimal percussion shape with billet
9		(15i) minimal percussion shape with cobble
9		(15ii) moderate percussion shape with cobble
9	(7ii) moderate pressure thin	(10ii) moderate percussion thin with billet
9		(13ii) moderate percussion thin with cobble
9	(9ii) moderate pressure shape	(13i) minimal percussion thin with cobble
9		(13ii) moderate percussion thin with cobble

TABLE II-26: CORRELATIONS: PRESSURE BEHAVIOURS

# Of Attributes Shared	Pressure Behaviours			
Strong Correlation				
9	(7i)	minimal pressure thin	(9i)	minimal pressure shape
9			(20i)	re-sharpening pressure over pressure
10	(7ii)	moderate pressure thin	(8)	substantial pressure thin
9			(9ii)	moderate pressure shape
* 10	* (8)	substantial pressure thin	(7ii)	moderate pressure thin
* 9½	* (9i)	minimal pressure shape	(7i)	minimal pressure thin
9½			(20i)	re-sharpening: pressure over pressure
* 9	* (9ii)	moderate pressure shape	(7ii)	moderate presssure thin
* 9	* (20i)	re-sharpening; pressure over pressure	(7i)	minimal pressure thin
* 9½	*		(9i)	minimal pressure shape
Weak Correlation				
5	(8)	substantial pressure thin	(9i)	minimal pressure shape
5½			(20i)	re-sharpening: pressure over pressure
Low Moderate				
6			(7i)	minimal pressure thin

* N.B. For the sake of clarity some of the correlated pairs were repeated.

TABLE II-27: PRESSURE THINNING VS PRESSURE SHAPING

MINIMAL FORCE LEVEL

THINNING	SHAPING
- limited frequency of edge damage; stepping only	- moderate frequency of edge damage; shattering, stepping, hinging
-limited frequency of microflakes	- no microflakes
- same ratio of straight and irregular distal edges, a few rounded ones	- distal edge mostly irregular
- scar termination either feathered or step	- mostly feathered flake scar termination

MODERATE FORCE LEVEL

THINNING	SHAPING
- flake scar size minimal to moderate	- small scar size (very minimal)
- edge damage frequency moderate to extensive	- bit lower frequency of edge damage: moderate
- bulb size ranges from very minimal to substantial	- slightly larger bulb size range: moderate to very substantial
- frequency of ribs presence is moderate to extensive	- ribs are present more often: extensive (frequency)
- straight or irregular distal edges only	- similar frequency of rounded, straight, and irregular distal edges
- mostly step flake scar termination	- mostly feathered scar termination

TABLE II-28: CORRELATIONS: PERCUSSION BEHAVIOURS

# Of Attributes Shared	Percussion Units	
Strong Correlations		
9½	(10i) minimal percussion thin with billet	(12ii) moderate percussion shape with billet
9		(15i) minimal percussion shape with cobble
9	(11) substantial percussion thin with billet	(15) substantial percussion thin with cobble
10	(12i) minimal percussion shape with billet	(15i) minimal percussion shape with cobble
* 9½	(12ii) moderate percussion shape with billet	(10i) minimal percussion thin with billet
9		(15ii) moderate percussion shape with cobble
10	(13i) minimal percussion thin with cobble	(13ii) moderate percussion thin with cobble
9		(15ii) moderate percussion shape with cobble
9½		(16i) moderate indirect percussion thin
* 10	(13ii) moderate percussion thin with cobble	(13i) minimal percussion thin with cobble
9		(15ii) moderate percussion shape with cobble
11		(16i) moderate indirect percussion thin
* 9	(14) substantial percussion thin with cobble	(11) substantial percussion thin with billet
* 9	(15i) minimal percussion shape with cobble	(10i) minimal percussion thin with billet
* 10		(12i) minimal percussion shape with billet
* 9	(15ii) moderate percussion shape with cobble	(12ii) moderate percussion shape with billet
* 9		(13i) minimal percussion thin with cobble
* 9		(13ii) moderate percussion thin with cobble
* 9½	(16i) moderate indirect percussion thin	(13i) minimal percussion thin with cobble
* 11		(13ii) moderate percussion thin with cobble
Weak Correlations		
5½	(10ii) moderate percussion thin with billet	(15ii) moderate percussion shape with cobble
4½	(14) substantial percussion thin with cobble	(10i) minimal percussion thin with billet

Cont'd

TABLE II-28, Cont'd

4½	(121) minimal percussion shape with billet
4	(1211) moderate percussion shape with billet
5½	(131) minimal percussion thin with cobble
5	(151) minimal percussion shape with cobble

* N.B. For the sake of clarity, some of the correlated pairs were repeated.

TABLE II-29: PERCUSSION THINNING VS SHAPING; BILLET VS COBBLE

Minimal Force Level

Thinning	Shaping
- moderate to extensive frequency edge damage	- shaping with cobble creates edge damage quite often (extensive) while the billet does not (absent)
- creates small bulbs as well as large ones	- large bulbs only
- thinning ribs tend to be less distinct (indistinct to moderately pronounced)	- shaping ribs tend to be more pronounced (moderately pronounced to pronounced)
- mostly irregular distal edges	- mostly rounded distal edges with the billet and similar ratio of irregular and rounded with the cobble

Moderate Force Level

Thinning	Shaping
- tearing is seen a bit more often (rare to limited)	- tearing seldom seen (absent or rare)
- straight, rounded and irregular distal edges found	- mostly rounded or irregular distal edges
- flake scar termination either step or feathered	- flake scar termination mostly feathered

Minimal Force Level

Billet	Cobble
- slightly higher frequencies of edge damage (extensive)	- thinning with the cobble produces edge damage less frequently than thinning or shaping with the billet or shaping with the cobble.
- platform collapse can occur or not	- platform collapse usually occurs
- produces mostly large bulbs of force (substantial to very substantial)	- can produce smaller bulbs (cobble thinning) (minimal to very substantial)
- rib distinctiveness ranges from indistinct to pronounced	- ribs usually moderately pronounced to pronounced

cont'd

TABLE [illegible]II-29, Cont'd

Moderate Force

Billet	Cobble
- edge damage quite frequent (extensive)	- edge damage less frequent (moderate)
- some microflakes seen, although rare to limited	- no microflakes
- ribs seen moderately often	- ribs also seen moderately often in thinning but very often (very extensive) in shaping
- ribs usually close together and on distal half of flake scar	- ribs can be either close together and on distal half of flake scar or close together and evenly distributed across scar
- distal edge is mostly rounded or irregular	- distal edge shows similar frequencies for straight, rounded or irregular

TABLE II-30: CORRELATIONS: EDGE UNITS

A) Strong Correlations (9-11/14)

		Attributes Shared
(1i) rub abrade with cobble	(1ii) rub buffet with cobble	: 10½
	(2ii) pressure rub with pr. fl.	: 9
	(3i) minimal shear thin with pr. fl.	: 9
	(3ii) minimal shear thin with cobble	: 9
	(4i) moderate shear thin with pr. fl.	: 9
	(5ii) minimal shear shape with cobble	: 10
(1ii) rub buffet with cobble	(1i) rub abrade with cobble	: 10½*
	(2i) rub buffet with billet	: 10½
	(2ii) pressure rub with pr. fl.	: 10
	(3i) minimal shear thin with pr. fl.	: 9
(2i) rub buffet with cobble	(1ii) rub buffet with cobble	: 10½*
	(2ii) pressure rub with pr. fl.	: 10½
	(3i) minimal shear thin with pr. fl.	: 9½
	(3ii) minimal shear thin with cobble	: 9½
	(4i) moderate shear thin with pr. fl.	: 9½
	(50) edge press on anvil	: 10
(2ii) pressure rub with pr. fl.	(1i) rub abrade with cobble	: 9 *
	(1ii) rub buffet with cobble	: 10
	(2i) rub buffet with billet	: 10½*
	(3i) minimal shear thin with pr. fl.	: 9
	(3ii) minimal shear thin with cobble	: 9½
	(4i) moderate shear thin with pr. fl.	: 10½
	(4ii) moderate shear thin with cobble	: 9
	(5i) minimal shear shape with pr. fl.	: 9
	(5ii) minimal shear shape with cobble	: 9
	(6i) moderate shear shape with pr. fl.	: 10
	(50) edge press on anvil	: 11
(3i) minimal shear thin with pr. fl.	(1i) rub abrade with cobble	: 9 *
	(1ii) rub buffet with cobble	: 9 *
	(2i) rub buffet with billet	: 9½*
	(2ii) pressure rub with pr. fl.	: 9 *
	(3ii) minimal shear thin with cobble	: 10
	(4i) moderate shear thin with pr. fl.	: 12
	(5i) minimal shear shape with pr. fl.	: 10½
	(5ii) minimal shear shape with cobble	: 9
	(50) edge press on anvil	: 9
(3ii) minimal shear thin with cobble	(1i) rub abrade with cobble	: 9 *
	(2i) rub buffet with billet	: 9½*
	(2ii) pressure rub with pr. fl.	: 9½*
	(3i) minimal shear thin with pr. fl.	: 10 *
	(4i) moderate shear thin with pr. fl.	: 11
	(4ii) moderate shear thin with cobble	: 10½
	(5i) minimal shear shape with pr. fl.	: 9½
	(5ii) minimal shear shape with cobble	: 9½
	(50) edge press on anvil	: 10½

Cont'd

TABLE II-30, Cont'd

(4i)	moderate shear thin with pr. fl.	(1i)	rub abrade with cobble	9 *
		(2i)	rub buffet with billet	9½*
		(2ii)	pressure rub with pr. fl.	10½*
		(3i)	minimal shear thin with pr. fl.	12 *
		(3ii)	minimal shear thin with cobble	11 *
		(4ii)	moderate shear thin with cobble	9
		(5i)	minimal shear shape with pr. fl.	9
		(5ii)	minimal shear shape with cobble	9½
		(50)	edge press on anvil	10½
(4ii)	moderate shear thin with cobble	(2ii)	pressure rub with pr. fl.	9 *
		(3ii)	minimal shear thin with cobble	10½*
		(4i)	moderate shear thin with pr. fl.	9 *
		(5ii)	minimal shear shape with cobble	9
		(6i)	moderate shear shape with pr. fl.	9
		(50)	edge press on anvil	10
(5i)	minimal shear shape with pr. fl.	(2ii)	pressure rub with pr. fl.	9 *
		(3i)	minimal shear thin with pr. fl.	10½*
		(3ii)	minimal shear thin with cobble	9½*
		(4i)	moderate shear thin with pr. fl.	10½*
		(50)	edge press on anvil	9½
(5ii)	minimal shear shape with cobble	(1i)	rub abrade with cobble	10 *
		(2ii)	pressure rub with pr. fl.	9 *
		(3i)	minimal shear thin with pr. fl.	9 *
		(3ii)	minimal shear thin with cobble	9½*
		(4i)	moderate shear thin with pr. fl.	9½*
		(4ii)	moderate shear thin with cobble	9 *
		(6ii)	moderate shear shape with cobble	9
(6i)	moderate shear shape with pr. fl.	(2ii)	pressure rub with pr. fl.	10 *
		(4ii)	moderate shear thin with cobble	9 *
		(50)	edge press on anvil	9
(6ii)	moderate shear shape with cobble	(5ii)	minimal shear shape with cobble	9 *
(50)	edge press on anvil	(2i)	rub buffet with billet	10 *
		(2ii)	pressure rub with pr. fl.	11 *
		(3i)	minimal shear thin with pr. fl.	9 *
		(3ii)	minimal shear thin with cobble	10½*
		(4i)	moderate shear thin with pr. fl.	10½*
		(4ii)	moderate shear thin with cobble	10 *
		(5i)	minimal shear shape with pr. fl.	9½*
		(6i)	moderate shear shape with pr. fl.	9 *

B) Weak Correlations (3-5/14)

(5i)	minimal shear shape with pr. fl.	(6ii)	moderate shear shape with cobble	5½

*: repeated above

TABLE II-31: CORRELATIONS: SHEARING BEHAVIOURS

Behaviour	Correlations (with behaviour # * :# of shared attributes						
	Same Tool	Same Force	Adjacent Force	Same Intent	Shear (all else different)	Rub Unit	Edge Pressure on Anvil
31	211 : 9 41 : 12 51 : 10.5	311 : 10 51 : 10.5 511 : 9	41 : 12	311 : 10 41 : 12.	----	11 : 9 111 : 9 21 : 9.5 211 : 9	50 : 9
311	11 : 9 411 : 10.5	31 : 10 51 : 9.5 511 : 9.5	411: 10.5	41: 11 411 :10.5	----	11 : 9 21 : 9.5 211 : 9	50 : 10.5
41	211 : 10.5 31 : 12 51 : 10.5	411 : 9	31 : 12	31 : 12 311 : 11 411 : 9	511 : 9.5	11 : 9 21 : 9.5 211 : 10.5	50 : 10.5
411	511 : 9	41 : 9 61 : 9	311 : 10.5	41 : 9	-----	211 : 9	50 : 10
51	211 : 9 31 : 10.5 41 : 10.5	31 : 10.5 311 : 9.5	----	----	----	211 : 9	50 : 9.5
511	11 : 10 311 : 9.5 411 : 9 611 : 9	31 : 9 311: 9.5	611 : 9	611 : 9	41 : 9.5	11 : 10 211 : 9	----
61	211 : 10	411 : 9	----	----	------	211 : 10	50 : 9
611	----	----	511 : 9	----	------	------	------

* 11 : rub abrade with cobble
111 : rub buffet with cobble
21 : rub buffet with antler billet
211 : pressure rub with antler pressure flaker
31 : minimal shear thin with antler pressure flaker
311 : minimal shear thin with cobble
41 : moderate shear thin with antler pressure flaker
411 : moderate shear thin with cobble
51 : minimal shear shape with antler pressure flaker
511 : minimal shear shape with cobble
61 : moderate shear shape with antler pressure flaker
611 : moderate shear shape with cobble
50 : edge press on anvil

TABLE II-33: COMPARATIVE SUMMARIZED DATA ON ALL BEHAVIOURS AND ATTRIBUTES

THINNING:	PERCUSSION		PRESSURE
	BILLET	COBBLE	
Edge Damage	fair bit: +,+,++* ⟶ F* same at min & mod, incr. at sub.force (+)*	fair bit:+-,+-,++ ⟶ F same at min & mod, incr. at subst. (+-)	less than perc.: -,+-/+,-/+- - ↗ +-/+ ↘ -/+- (-)
Platform Collapse	not much: STR, STR, FL.C.* starts at subst. ⟶ F (-) (3)*	bit more: STR,FL.C,FL.C starts at mod. ⟶ F (+-) (2)	more: ½STR/½FL.C., FL.C, U-NOTCH starts at min. ⟶ F (+) (1)
Ribs Presence	fair bit:+-/+,+-, ++:(at least mod.) +-/+ ↘ +- ↗ ++ (+)	fair bit:+,+-,++ (at least mod.) + ↘ +- ↗ ++ (+)	bit less: -,+-/+,+ (range varies more: rare to ext.) ⟶ F (+-)
Ribs Distinctiveness	IND. to PRON. (slight incr. with force:⟶ F) (+-)	mostly MOD. to PRON. (about same at all force levels: ⟷ F) (+)	mostly INDIST. (2 behav. yield MOD.) ⟷ F (-)
Ribs Spacing	CL & D½ only ⊃ (all behav., all force levels)	CL & D½/CL & E, CL & D½/CL & E, CL & E (⊃) (more CL & E)⊃⊃	mostly CL & E/ CL & D½ (F & D½ at sub. force only) ⊃⊃ ⊃
Bulb Presence	least dist. at mod.: +- ↘ - ↗ + min mod sub N.V.: 2 4 1 =7 INT.: 0 1 1½ =2½ DIST: 2 2 1½ =5½ (3) (+-)	⟶ F min mod sub N.V.: 3 2 0 =5 INT.: 1 0 0 =1 DIST: 2 4 3 =9 (1) (+)	⟶ F min mod sub N.V.: 8 2 2 =12 INT.: 1 0 6 =7 DIST: 0 2 5 =7 (2) (+-)
Bulb Size	+/++,-/+,-/+-/+ :min to v. subst. ↖ ⟷ (+-)	-/+-/++,-/+-/++, -/+: min - v.sub. ⟷ ↘ (+-)	(+-),-/+,+-/+: v. min to subst. (mostly mod - sub.) avg, larger than perc.; ⟶ F (+)
Distal Shape	IRR, IRR, RD (more RD with increased force)	IRR, IRR/STR/RD, RD/IRR (more RD with force; STR. only at MOD.)	STR/RD/IRR,STR/IRR, STR/IRR (less RD. with incr. force)
Termination	FEATH, ST, FEATH (ST. at mod. force level only)	ST/F, F/some ST, ST/F (about same at all force lev.)	ST/F, ST, ST (more STEP with increased force)

Cont'd

TABLE II-33, Cont'd

SHAPING:	PERCUSSION		PRESSURE
	BILLET	COBBLE	
Edge Damage	fair bit: +, ++ ⟶ F (+)	fair bit: +, +- (bit less than billet) ⟵ F (+-)	moderate: +-, +- (less than percussion) ⟷ F (-)
Platform Collapse	none visible: STR, STR (flake overlapping) ⟷ F (-) (3)	little visible: STR, ½STR/½FL.C. (flake overlapping) ⟶ F (+-) (2)	½STR/½FL.C., FL.C.: more than perc. starts at min. force bit ⟶ F (+) (1)
Ribs Presence	not much: -, +- ⟶ F (-)	-, ++ : big diff. from min. to mod. force level ⟶ F (+)	-, + : fair diff. from min. to mod. force level ⟶ F (+-)
Ribs Distinctiveness	PRON., IND.:sharp decr. in dist. with incr. force ⟵ F (+-)	VAR(MOD/PRON),IND :fairly sharp diff. between min & mod ⟵ F (+-)	IND, VAR(IND/VAR): not very distinct bit ⟶ F (-)
Ribs Spacing	X, CL & D½	(F & D½), CL & E (1 scar) 	CL & D½, CL & D½/ CL & E
Bulb Presence	⟶ F min mod N.V.: 8 3 = 11 INT.: 2 3 = 5 DIST: 0 4 = 4 (3) (+-)	⟶ F min mod N.V.: 5 1 = 6 INT.: 2 4 = 6 DIST: 4 2 = 6 (1) (+)	⟶ F min mod N.V.: 9 3 = 12 INT.: 4 2 = 6 DIST: 0 4 = 4 (2) (+-)
Bulb Size	+-/+ , - to ++ :min. to v. subst. (mostly mod. to v. subst.) (⟶ F ?) (+-)	- to ++, - to ++ :min. to v. subst. (mostly mod. to v. subst.) ⟵ F (+-)	- to ++, +- to ++ :min. to V. Subst. (mostly mod. to v. subst.) ⟶ F (+-)
Distal Shape	RD., RD. (same at either force level)	IRR/RD, IRR/RD (same at either force level)	IRR, STR/RD/IRR (STR & RD appear at mod force)
Termination	F/ST, F (STEP at min. force level only)	F, F (FEATHERED only)	F, F (FEATHERED only)

Cont'd

TABLE II-33, Cont'd

* : Code for the understanding of Table II-33

- : ABSENT, LIMITED, or MINIMAL (and VERY MINIMAL)
+-: MODERATE
+ : EXTENSIVE or SUBSTANTIAL
++: VERY EXTENSIVE or VERY SUBSTANTIAL

⟶ F : .... increases with increased force (e.g.'edge damage increases from minimal to moderate to substantial force levels')
⟵ F : .... decreases with increased force
⟷ F : .... remains the same regardless of force level used

∧→ ←∧ : .... greatest at moderate force (1st case: least at minimal force; 2nd case: least at substantial force)

∨→ ←∨ : .... least at moderate force (1st case: greatest at minimal force; 2nd case: greatest at substantial force)

(-), (+-), (++) : refers to ranking of the percussion with billet, percussion with cobble, and pressure behaviours for a particular attribute
e.g. edge damage: billet cobble pressure :
(+) (+-) (-)
signifies that edge damage is greatest in the behaviours using percussion with the billet, and least in those using pressure flaking
e.g. ribs presence: billet cobble pressure :
(+) (+) (+-)
signifies that ribs are seen often on all behaviours, but more so on the percussion behaviours, the frequencies being similar for billet and cobble percussion

(1), (2), (3) : is also a ranking criterion but refers to the timing of a particular attribute, rather than to a quantity (for instance pressure thinning and percussion thinning with the billet have similar frequencies of bulb presence, but these appear at a lower force level in pressure than in percussion with the billet: pressure thinning therefore receives a ranking of (2) for timing while percussion thinning with billet receives a timing ranking of (3).)

+, +-, ++ (etc.) : refers to the characteristic attributes at each force level: that is to say, the value before the first ',' refers to the minimal force level, the next value refers to the moderate force level, and the last value (i.e. after the 2nd ',') refers to the substantial force level.
e.g. +-, +, - (for edge damage) would signify: moderate edge damage at minimal force, extensive at moderate, and minimal edge damage at substantial force.

TABLE II-34: VIDEOTAPE INFORMATION (MANUFACTURING PROCESS, KNIFE RIVER FLINT COLLECTION)

				PLATFORM PREPARATION: TYPE	TOOL: A)TYPE B)SHAPE C)PORTION USED	ANGLE	SUPPORT SYSTEM: A)TYPE B)STRENGTH	FAILED SCARS: A)CRUSHING B)MANY TRIES C)WRONG FORCE
PERCUSSION	thinning	minimal	bil 101	X	A)4 B)1 C)edge perimeter or bump	2) to 4)	A)3 B)2	A)1 B)many
			cob 131	X	A)6 B)3 C)rounded side	2) to 4)	A)3 B)2	A)10 B)23/26 tries unsuccessful
		moderate	bill. 1011	X	A)4 B)1 C)edge perimeter or bump	2) to 4)	A)3 B)2	B)many
			cob. 1311	A)2 (bit) with rounded side of cobble	A)6 B)3 C)rounded side	2) to 4)	A)3 B)2	A)14 B)24-25/32 tries unsuccessful C)# of flakes too long
		substantial	bill. 11	A)1 ⟷ cobble A)2 ↓ cobble A)3 (#4) billet	A)5 B)1 bit bevelled C)perimeter (edge)	about 2)	A)4 B)1	A)2 B)2-3/7 blows unsuccessful
			cob. 14	A)1 ⟷ (scar #4) with rounded side of cobble	A)6? B)3 C)rounded side	2)	A)3 B)2	A)1 B)9/13 blows unsuccessful
	shaping	minimal	bil 121	X	A)4 B)1 C)bump on surface of end	2)	A)3 B)2	A)1
			cob 151	X	A)6 B)3 C)rounded side	2) or maybe 4)	A)3 B)2	A)5 B)many
		moderate	bill. 1211	X	A)4 B)1 C)bump on surface of end	2)	A)3 B)2	A)3
			cob. 1511	X	A)6 B)3 C)rounded side	2) or maybe a bit less	A)3 B)2	A)7 B)many

Cont'd

TABLE II-34, Cont'd

			PLATFORM PREPARATION: TYPE	TOOL: A)TYPE B)SHAPE C)PORTION USED	ANGLE	SUPPORT SYSTEM: A)TYPE B)STRENGTH	FAILED SCARS: A)CRUSHING B)MANY TRIES C)WRONG FORCE
INDIRECT	PERC. THIN.	mod 16i	X	A)5 B)1 C)perimeter at end	3)	A)2 B)1	A)4 B)# of tries C)2nd series more subst. than mod.
		subst 16ii	16-1: A)1 ⟷ entire edge (file) (strengthening) 16-2: X	A)5 B)1 C)perimeter at end	3)	A)2 B)1	16-1: B)few tries required 16-2: B)got it on 5th try C)trying for min. but could only get mod.-subst.
PRESSURE	thinning	min 7i	X	A)1 B)2 C)tip	2) to 3)	A)1 B)2	A)4
		mod 7ii	A)3 (1 flake only)	A)1 B)2 C)tip	3)	A)1 B)2	A)1 B)1 (flake #1) C)1 (flake #2): more subst. than moderate
		subst 8	1st attempt: X 2nd: A)3 A)1 ⟷ (in diff. areas)	1st attempt: A)1 B)2 C)tip 2nd: A)2 B)2-3	3)	A)1 B)2	1st attempt: no success, A)1 2nd: B)
	shaping	min 9i	X	A)3 B)1 C)tip	3)	A)1 B)2	A)1
		mod 9ii	X	A)3 B)1 C)tip	3)	A)1 B)2	B)went over a few times in 2 areas
RE-SHARP	PRESS./PRESS.	20i	edge prepared (pressure) before painted	A)7 B)2 C)tip	3)	A)1 B)2	B)some attempts unsuccessful

Cont'd

TABLE II-34, Cont'd

PLATFORM PREPARATION TYPE:

A) Edge Dulling: 1- rub abrade; 2-rub buffet; 3- pressure rub
B) Edge Thickening: 1- pressure or percussion; 2- shearing
C) Edge Angle Reducing

TOOL:

A) Type: 1- small, pointed antler billet with squared tip; 2- slightly larger and pointier antler billet with wrapped grip; 3- larger antler billet with wrapped grip; 4- larger tibia-shaped antler billet; 5- very large billet; 6- split cobble; 7- antler billet, medium size, wrapped handle, straight
B) Shape: 1- flat; 2- pointed; 3- rounded
C) Portion Used: (see comments in that section)

ANGLE: (of flaking tool to flaked artifact)
1) parallel to edge; 2) 90°; 3) less than 90°; 4) greater than 90°

SUPPORT SYSTEM:
A) Type: 1- artifact held down against palm with 3 fingers; hand on lap.
2- artifact held with leather pad between knees; punch tool resting on artifact and held in left hand; percussion tool held in right hand (INDIRECT PERCUSSION).
3- artifact held horizontally between thumb and fingers; hand on lap.
4- artifact resting on pad placed on lap; held on top by entire hand.
B) Strength: 1- very strong; 2- strong; 3- fairly strong; 4- weak

FAILED SCARS:

A) Platform Crushing: # of flakes with crushed platform areas.
B) Many Tries: going over the same area repeatedly; # of unsuccessful attempts.
C) Wrong Force: wrong force level used; # of flakes where this occurs.

TABLE II-35: PLATFORM PREPARATION: PERCUSSION VS PRESSURE

<table>
<tr><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">POSSIBILITIES</td><td colspan="3">CASES</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td colspan="3">EDGE DULLING **</td></tr>
<tr><td>A1) Rub Abrade</td><td>A2) Rub Buffet</td><td>A3) Pressure Rub</td></tr>
<tr><td rowspan="3">PERCUSSION</td><td>Thinning</td><td>6</td><td>1.3 *** or 22%</td><td>1.3 or 22%</td><td>0.3 or 6%</td><td>3/6 or 50%</td><td></td><td rowspan="3">4/13 or 31% of Percussion</td></tr>
<tr><td>Indirect Thinning</td><td>3</td><td>1 or 33%</td><td></td><td></td><td>1/3 or 33%</td><td></td></tr>
<tr><td>Shaping</td><td>4</td><td></td><td></td><td></td><td></td><td>0/4 or 0%</td></tr>
<tr><td rowspan="3">PRESSURE</td><td>Thinning</td><td>3</td><td>0.5 or 17%</td><td></td><td>1.5 or 50%</td><td>2/3 or 67%</td><td></td><td rowspan="3">3/6 or 50% of Pressure</td></tr>
<tr><td>Re-Sharpening</td><td>1</td><td colspan="3">1 or 100%: type unknown, edge preparation done during manufacturing of biface, before painting, and unrecorded</td><td colspan="2">1/1 or 100%</td></tr>
<tr><td>Shaping</td><td>2</td><td></td><td></td><td></td><td></td><td>0/2 or 0%</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td>6/12 or 50% of Thinning</td><td>0/6 or 0% of Shaping</td><td></td></tr>
</table>

* 2 samples of 1611

** no other type of edge preparation was observed

*** where more than one technique was used to prepare an edge, the edge itself was considered the entity, and not each one of the preparation techniques eg. if 1 of 6 artifacts had undergone 3 types of edge preparation, say rub abrade, rub buffet, and pressure rub, the table would read:

Possibilities	Rub Abrade	Rub Buffet	Pressure Rub
6	.3 or 6%	.3 or 6%	.3 or 6%

Had each technique been taken as a whole instead, the table would have shown that 3 of the 6 artifacts (50% instead of 17 or 18%) had undergone platform preparation, which is erroneous.

TABLE II-36: ANGLE OF FLAKING TOOL TO ARTIFACT:
PERCUSSION VS PRESSURE; THINNING VS SHAPING

		Possibilities	CASES				
			>90°	90°	<90°		
					89-76.6°	67.5-46°	45-0°
PERCUSSION	Thinning	6		.8 or 13%	2.8 or 47%	2.3 or 38%	
	Indirect Thinning	3*					** 3 or 100%
	Shaping	4		1 or 25%	3 or 75%		
PRESSURE	Thinning	3				2 or 67%	1 or 33%
	Re-Sharpening	1					1 or 100%
	Shaping	2					2** or 100%
	Percussion			1.8/13 or 14%	5.8/13 or 45% (8.8/13 or 68%)	2.3/13 or 18%	3**/13 or 23% (0%)
	Pressure				(2/6 or 33%)	2/6 or 33%	4/6 or 66% (2 = **) (33%)
***	Thinning			.8/12 or 23% (5.8/12 or 48%)	2.8/12 or 23% (5.8/12 or 48%)	4.3/12 or 36%	(3 = **) 4/12 or 33% (8%)
	Shaping				3/6 or 50% (5/6 or 88%)	—	2/6** or 33% (0%)

* includes 2 samples of 16ii

** small angle but the pressure is directed downwards; this makes the angle between the artifact and force applied closer to the 90° mark

*** re-sharpening (20%) not included as it is morphologically as close to thinning as it is to shaping

TABLE II-37: ANGLE OF FLAKING TOOL TO ARTIFACT: PERCUSSION VS PRESSURE (SUMMARY)

	90°	67.6-89°	46-67.6°	0-45°
PRESSURE	---	33%	33%	33%
PERCUSSION	14%	68%	18%	---

TABLE II-38: SUPPORT SYSTEM: PERCUSSION VS PRESSURE

		Possi-bili-ties	CASES				
			Very Strong		Strong		Strength
			(4)	(2)	(1)	(3)	Type
PERCUSSION	Thinning	6	1 or 17%			5 or 83%	
	-indirect- Thinning	3*		3 or 100%			
	Shaping	4				4 or 100%	
PRESSURE	Thinning	3			3 or 100%		
	Re-sharpening	1			1 or 100%		
	Shaping	2			2 or 100%		
Percussion	Type		¼ or 25%	3/4 or 75%		9/9 or 100%	
	Strength		4/13 or 31%		9/13 or 69%		
Pressure	Type				6/6 or 100%	---	
	Strength				6/6 or 100%		
Thinning	Type		¼ or 25% 1/12 or 8%	3/4 or 75% 3/12 or 25%	3/8 or 38% 3/12 or 25%	5/8 or 62% 5/12 or 42%	
	Strength		4/12 or 33%		8/12 or 67%		
Shaping	Type				2/6 or 33%	4/6 or 67%	
	Strength				6/6 or 100%		

* 2 samples of 16ii

TABLE II-39: FAILED SCARS: PERCUSSION VS PRESSURE

		Possi-bilities	CASES			
			A) PLATFORM CRUSHING	B) MANY TRIES		C) WRONG FORCE
				Many	V. few	
PERCUSSION	Thinning	6	28/65 flake scars or 43%	5 or 83%	1 or 17%	1 or 17%
	-Indirect-Thinning	3*	4/13 flake scars or 31%	2 or 66%	1 or 33%	
	Shaping	4	16/87 flake scars or 18%	2 or 50%		2 or 50%
PRESSURE	Thinning	3	6/41 flake scars or 15%		3 or 100%	1 or 33%
	Re-Sharpening	1	0/16 flake scars or 0%			
	Shaping	2	1/26 flake scars or 4%		1 or 50%	
Percussion			48/165 flake scars or 29%	9/13 or 69%	2/13 or 15%	2/13 or 23% of behaviours; 2-4% of flakes
Pressure			7/83 flake scars or 8%	0/6 or 0%	4/6 or 67%	1/6 or 17% of behaviours; 1-2% of flakes
Thinning			38/119 flake scars or 32%	7/12 or 58%	5/12 or 42%	2/12 or 17% of behaviours; 1-2% of flakes
Shaping			17/113 flake scars or 15%	2/6 or 33%	1/6 or 17%	2/6 or 33% of behaviours; 2-5% of flakes

*: 2 samples of 16ii

TABLE II-40: PLATFORM PREPARATION: BILLET VS COBBLE

	Possibilities	CASES			
		EDGE DULLING*			
		A1 Rub Abrade	A2 Rub Buffet	A3 Pressure Rub	
BILLET	5	.3** or 6%	.3 or 6%	.3 or 6%	1 behaviour in 5 or 20%
COBBLE	5	1 or 20%	1 or 20%	---	2 behaviours in 5 or 40%
					3 behaviours in 10 or 30%

* no other type of edge preparation was observed

** (see Table II-35 about fractions)

TABLE II-41: ANGLE OF FLAKING TOOL TO ARTIFACT: BILLET VS COBBLE

	POSSIBILITIES	CASES				
		>90°	90°	<90°		
				89°-67.6°	67.5°-46°	45°- 0°
BILLET	5		1 or 20%	4 or 80%		
COBBLE	5		.8 or 17%	1.8 or 37%	2.3 or 47%	

TABLE II-42: SUPPORT SYSTEM: BILLET VS COBBLE

	POSSIBILITIES	CASES				
		VERY STRONG		STRONG		Strength
		4	2	1	3	Type
BILLET	5	1 or 20%			4 or 80%	
COBBLE	5				5 or 100%	

TABLE II-43: FAILED SCARS: BILLET VS COBBLE

	POSSIBILITIES	CASES			
		A) Platform Crushing	B) Many tries		C) Wrong Face
			MANY	VERY FEW	
BILLET	5	7/62 flake scars or 11%	2 or 40%	2 or 40%	
COBBLE	5	37/90 flake scars 04 41%	5 or 100%		1 or 20%

TABLE II-44: DISTAL EDGE SHAPE

	PERCUSSION WITH COBBLE			PERCUSSION WITH BILLET			PRESSURE		
SHAPE OF DISTAL EDGE	MIN	MOD	SUB	MIN	MOD	SUB	MIN	MOD	SUB
STRAIGHT	1*	3		2	3		8	5	5
STRAIGHT OR ROUNDED							1		
ROUNDED	6	8	2	6	9	3	6	3	2
ROUNDED OR IRREGULAR							1		
IRREGULAR	12	7	1	6	9	1	20	5	5
IRREGULAR TO STRAIGHT							2		1

* : number of flake scars

APPENDIX III

PHOTOGRAPHIC TECHNIQUES

Most of the analysis of the Knife River flint experimental collection was conducted from stereo photographs. These provided the analyst with a permanent record of what was seen and coded on each flake scar. With the help of a stereo viewer, these photographs also offered a three-dimensional image of each experimental tool, thus facilitating the analysis. This appendix describes the techniques and equipment used during the photographic sessions. Many of these techniques were devised with the help of Brian Noble of Edmonton.

A) Equipment

The following is a list of all the equipment used in the coating and the photographic procedures.

Minolta SRT 101 camera
58 mm. Minolta lens (no filters required)
Vivitar Macro-focusing Teleconverter (2X)
Minolta camera stand
Cable release
Plus-X black and white film (ASA: 125)
White plexiglass box (diffusion box)

Tilting stage

Black velvet square

Rulers (scale)

Coating device: glass bulb with tubes at both ends,
one end attached to a rubber bulb

Ammonium chloride

B) Techniques

1) Coating

Because Knife River flint is a translucent material, a thin coat of ammonium chloride powder was used to cover the surface of the flake scars so only surface morphology would stand out. In order to do this, a small amount of ammonium chloride is put in the glass bulb segment of the coating apparatus. The chemical is heated until a white cloud of the material begins to emerge from a tapered tube at the end of the glass bulb. The artifact is moved over the powder stream until completely coated by the fine white powder. Humidity greatly affects this type of coating: one must, therefore, ensure the coated artifact does not come in contact with moisture until the coating can be removed. This can be accomplished by simply dipping the artifact in water.

2) Photography (see Fig. 2)

The Macro-focusing Teleconverter doubles the focal length of the 58 mm. lens and offers a reproduction scale of up to 1:1. For the purpose of this research, the Teleconverter was set at 1:1.8, and the focal distance of the 58 mm. lens was set at infinity.

The camera stand and cable release are used to minimize camera movement since the exposure time is quite long (1/2 second). The camera is pointed down, towards the upper surface of the artifact.

The artifact is placed on a stage that can be tilted to either side in order to achieve the desired three-dimensional effect when the photographs are viewed through a stereo viewer (see Fig. 1). The artifact is placed on a vertical peg set in an horizontal rod. The exact angle of tilting of this rod (i.e. the 'stage') is given by an angle indicator located on the device. The pegs are removable and can be relocated elsewhere along the rod. Larger artifacts may require the support of more than one peg. A small amount of plasticine helps hold the artifact to the peg. The pegs, as well as the entire background, are covered with black velvet in order to provide a neutral background.

A white translucent plexiglass box is placed around the artifact to diffuse the light and avoid burnout and light reflection from the artifact. Small desk lamps are placed on all sides of this box and aimed so the surface features of each flake scar will be highlighted by a mixture of light and shadow.

In order to retain the same scale for all photographs, the distance from camera to tilting stage is set for the largest artifact and remains unchanged throughout the entire session.

To achieve the three-dimensional effect, a photograph is taken while the artifact is tilted 5 degrees to the left, and a second photograph is taken while the artifact is tilted 5 degrees to the right.

The exposure time is 1/2 a second for all photographs. The aperture size depends on the camera's light meter reading. A smaller aperture (i.e. higher f stop number) is favoured, if possible, since it increases the depth of field. One photograph (for each tilting angle) is taken at the proper exposure, and a second photograph is taken a full stop higher (i.e. under-exposed by one stop) in order to compensate for the black background. The better set of negatives can be printed.

Copious notes were taken during the photographic sessions in order to be able to replicate the exact conditions, or alter them if necessary.

The photographs taken in this fashion proved a valuable tool in the analysis of the Knife River flint experimental collection.

APPENDIX IV

KNIFE RIVER FLINT DATA

Photocopies of all original coding sheets are stored with the Project for the Study of Material Culture, Department of Anthropology, University of Alberta, Edmonton.

EDGE RUB BEHAVIOURS

		Rub Abrade Cobble 1i 14 flakes	Rub Buffet		Pressure Rub Pr. Fl. 2ii 11 flakes
			Cobble 1ii 21 flakes	Billet 2i 5 flakes	
FLAKE SCAR SIZE:	V. MIN.* :	14 flakes	21	5	10
	MINIMAL :				1
	MODERATE :				
	SUBST. :				
	V. SUBST. :				
SHARPNESS OF PROX. EDGE:	SHARP :				8
	INTERM. :	4	19	5	2
	DULL :	10			
PROXIMAL MARGIN DAMAGE:	ABS./RARE:	X			
	LIMITED :				
	MODERATE :		X (small)	X	X
	EXTENSIVE:				
	V. EXT. :				
MICRO-FLAKES:	ABS./RARE:	X	X (small)	X	X
	LIMITED :				
	MODERATE :				
	EXTENSIVE:				
	V. EXT. :				
MORPHOLOGY OF PROXIMAL EDGE:	STRAIGHT :	10	14	4	6
	U-NOTCH :				1
	FL. CURVE:	3	4	1	3
	CONV.PROJ:				
	OTHER :				
PLATFORM COLLAPSE	N/A :	1	3		1
	ABSENT :	4	2	1	4
	PRESENT :	9	14	4	6
	PARTIAL :		1		
	UNKNOWN :		1		
DISTINCTIVENESS OF BULB:	NOT VIS. :	11	mostly N/A	4	5
	INTERM. :	1		1	2
	DISTINCT :	1	2		2
BULB SIZE:	V. MIN. :			1	
	MINIMAL :				
	MODERATE :	1			3
	SUBST. :		2		
	V. SUBST. :	1			2

* See Table 1 for abbreviated terms

EDGE RUB BEHAVIOURS, Cont'd

		Rub Abrade	Rub Buffet		Pressure Rub
		Cobble 1i 14 flakes	Cobble 1ii 21 flakes	Billet 2i 5 flakes	Pr.-Fl. 2ii 11 flakes
RIBS: PRESENCE:	ABS./RARE:	X			
	LIMITED :		X		
	MODERATE :			X	X
	EXTENSIVE:				
	V. EXT. :				
RIBS: DISTINCTIVENESS:	INDIST. :		1	1	1
	MOD. DIST:		1		2
	PRON. :				
	VARIABLE :	1		1	
RIBS: SPACING:	F & E :				
	F & D½ :				
	CL & E :	1			1
	CL & D½ :			1	1
	VARIABLE :			1	
	OTHER :				
TEARING:	ABS./RARE:	X	X	X	X
	LIMITED :				
	MODERATE :				
	EXTENSIVE:				
	V. EXT. :				
DISTAL EDGE SHAPE:	STRAIGHT :	4	6	1	2
	ROUNDED :	7	2 5	1 2	6
	IRREGULAR:	1	2	1	3
		to STR: 1 1	to STR: 1		
TERMINATION:	FEATHERED:	2 11	4 14	2 1	8
	STEP :	1	3	2	3

SHEAR THINNING BEHAVIOURS

		Minimal		Moderate	
		Pr. Fl. 3i 19 flakes	Cobble 3ii 25 flakes	Pr. Fl. 4i 20 flakes	Cobble 4ii 21 flakes
FLAKE SCAR SIZE:	V. MIN. :	19	25	20	21
	MINIMAL :				
	MODERATE :				
	SUBST. :				
	V. SUBST. :				
SHARPNESS OF PROX. EDGE:	SHARP :	19	22	20	19
	INTERM. :				2
	DULL :		1		
PROXIMAL MARGIN DAMAGE:	ABS./RARE :				
	LIMITED :	X		X	
	MODERATE :				
	EXTENSIVE :		X		X
	V. EXT. :				
MICRO-FLAKES:	ABS./RARE :	X	X	X	X
	LIMITED :				
	MODERATE :				
	EXTENSIVE :				
	V. EXT. :				
MORPHOLOGY OF PROXIMAL EDGE:	STRAIGHT :	15	18	14	7½
	U-NOTCH :				
	FL. CURVE :	4	4	4	9½
	CONV.PROJ :				
	OTHER :		1	2	3
PLATFORM COLLAPSE:	N/A :		2		
	ABSENT :	11	12	9	6
	PRESENT :	8	11	11	14
	PARTIAL :				1
	UNKNOWN :				
DISTINCTIVENESS OF BULB:	NOT VIS. :	11	15	14	11
	INTERM. :	3	5	3	3
	DISTINCT :	4	3	1	6
BULB SIZE:	V. MIN. :				
	MINIMAL :	2	2 2	2	1 2
	MODERATE :	3	2	1 2	1 2
	SUBST. :	2	2		2
	V. SUBST. :			1	2

SHEAR THINNING BEHAVIOURS, Cont'd

		Minimal		Moderate	
		Pr. Fl. 3i 19 flakes	Cobble 3ii 25 flakes	Pr. Fl. 4i 20 flakes	Cobble 4ii 21 flakes
RIBS:	ABS./RARE:				
PRESENCE:	LIMITED :				
	MODERATE.:	X	X	X	
	EXTENSIVE:				X
	V. EXT. :				
RIBS:	INDIST. :	1 2	6	1 5	1 7
DISTINCT-IVENESS:	MOD. DIST:	1	4		3
	PRON. :	1	1		1
	VARIABLE :				
RIBS:	F & E :				
SPACING:	F & D½ :				3
	CL & E :	1	8	2	4
	CL & D½ :	3		1	5
	VARIABLE :				
	OTHER :				
TEARING:	ABS./RARE:	X	X	X	X
	LIMITED :				
	MODERATE :				
	EXTENSIVE:				
	V. EXT. :				
DISTAL EDGE SHAPE:	STRAIGHT :	6	8	1 7	1
	ROUNDED :	10	10	1 7	9
	IRREGULAR:	2 to STR: 1	to STR: 6 1	to STR: 4 1	to STR: 1 10
TERMIN-ATION:	FEATHERED:	15	9	14	5 6
	STEP :	4	16	6	10

SHEAR SHAPING BEHAVIOURS

		Minimal		Moderate	
		Pr. Fl. 5i 12 flakes	Cobble 5ii 16 flakes	Pr. Fl. 6i 13 flakes	Cobble 6ii 10 flakes
FLAKE SCAR SIZE:	V. MIN. :	12	16	13	10
	MINIMAL :				
	MODERATE :				
	SUBST. :				
	V. SUBST. :				
SHARPNESS OF PROX. EDGE:	SHARP :	11	1	2 9	
	INTERM. :		4	1	3
	DULL :		11		7
PROXIMAL MARGIN DAMAGE:	ABS./RARE:	X			
	LIMITED :				
	MODERATE :			X	
	EXTENSIVE:		X		X
	V. EXT. :				
MICRO-FLAKES:	ABS./RARE:		X	X	X
	LIMITED :	X			
	MODERATE :				
	EXTENSIVE:				
	V. EXT. :				
MORPHOLOGY OF PROXIMAL EDGE:	STRAIGHT :	7	14	6½	7
	U-NOTCH :				
	FL. CURVE:	5	1	1 6½	2
	CONV.PROJ:				
	OTHER :	1			1
PLATFORM COLLAPSE:	N/A :	1	1	1	
	ABSENT :	5	10	3	1
	PRESENT :	6	5	9	9
	PARTIAL :				
	UNKNOWN :				
DISTINCTIVENESS OF BULB:	NOT VIS. :	9	10	6	1
	INTERM. :	2	1	3	7
	DISTINCT :		5	4	2
BULB SIZE:	V. MIN. :		1	1	
	MINIMAL :	2	1 2	5	3
	MODERATE :		2		4
	SUBST. :			2	1
	V. SUBST. :		1		

SHEAR SHAPING BEHAVIOURS, Cont'd

		Minimal		Moderate	
		Pr. Fl. 5i 12 flakes	Cobble 5ii 16 flakes	Pr. Fl. 6i 13 flakes	Cobble 6ii 10 flakes
RIBS: PRESENCE:	ABS./RARE:				
	LIMITED :				
	MODERATE :	X			
	EXTENSIVE:		X	X	
	V. EXT. :				X
RIBS: DISTINCT-IVENESS:	INDIST. :	2	1 4	2 7	3 1
	MOD. DIST:	3	2		2
	PRON. :				
	VARIABLE :		1		1
RIBS: SPACING:	F & E :				
	F & D½ :				1
	CL & E :		3	1	4
	CL & D½ :	5	4	6	2
	VARIABLE :				
	OTHER :				
TEARING:	ABS./RARE:	X	X	X	X
	LIMITED :				
	MODERATE :				
	EXTENSIVE:				
	V. EXT. :				
DISTAL EDGE SHAPE:	STRAIGHT :	2 7	1	2 2	2
	ROUNDED :	3	1 10	3 3	4
	IRREGULAR:	3	4	3	4
TERMIN-ATION:	FEATHERED:	1 5	3 9	1 9	3 5
	STEP :	6	4	2	2

PRESSURE

		THINNING			SHAPING	
		Minimal 7i 9 flakes	Moderate 7ii 4 flakes	Subst. 8 13 flakes	Minimal 9i 13 flakes	Moderate 9ii 9 flakes
FLAKE SCAR SIZE:	V. MIN. :	7		1	12	7
	MINIMAL :	2	2	6	1	2
	MODERATE :		2	5		
	SUBST. :			1		
	V. SUBST.:					
SHARPNESS OF PROX. EDGE:	SHARP :	9	4	13	13	9
	INTERM. :					
	DULL :					
PROXIMAL MARGIN DAMAGE:	ABS./RARE:					
	LIMITED :	X				
	MODERATE :		X	X	X	X
	EXTENSIVE:					
	V. EXT. :					
MICRO-FLAKES:	ABS./RARE:				X	
	LIMITED :	X	X	X		X
	MODERATE :					
	EXTENSIVE:					
	V. EXT. :					
MORPHOLOGY OF PROXIMAL EDGE:	STRAIGHT :	4		1	4	1
	U-NOTCH :		1	2 5		1 1
	FL. CURVE:	4	3	4	6	1
	CONV.PROJ:					
	OTHER :	1		1	3	1
PLATFORM COLLAPSE:	N/A :					
	ABSENT :	1		1	3	
	PRESENT :	8	4	11	9	9
	PARTIAL :			1	1	
	UNKNOWN :					
DISTINCTIVENESS OF BULB:	NOT VIS. :	8	2	2	9	3
	INTERM. :	1		6	4	2
	DISTINCT :		2	5		4
BULB SIZE:	V. MIN. :		1			
	MINIMAL :				1	
	MODERATE :	1		2 4	1	1 2
	SUBST. :		1	5	1 1	1
	V. SUBST.:					2

PRESSURE, Cont'd

		THINNING			SHAPING	
		Minimal 7i 9 flakes	Moderate 7ii 4 flakes	Subst. 8 13 flakes	Minimal 9i 13 flakes	Moderate 9ii 9 flakes
RIBS: PRESENCE:	ABS./RARE:	X				
	LIMITED :				X	
	MODERATE :		X			
	EXTENSIVE:			X		X
	V. EXT. :					
RIBS: DISTINCTIVENESS:	INDIST. :	1	2	5	2	3
	MOD. DIST:			2		
	PRON. :					
	VARIABLE :					2
RIBS: SPACING:	F & E :					
	F & D$\frac{1}{2}$:			1		
	CL & E :		1	3		3
	CL & D$\frac{1}{2}$:		1	2	2	2
	VARIABLE :					
	OTHER :					
TEARING:	ABS./RARE:	X	X		X	X
	LIMITED :			X		
	MODERATE :					
	EXTENSIVE:					
	V. EXT. :					
DISTAL EDGE SHAPE:	STRAIGHT :	3	2	5	3	3
	ROUNDED :	1 2		2	3	3
	IRREGULAR:	3	2	to^{5}STR:1	7	3
TERMINATION:	FEATHERED:	4	1	3 3	11	2 5
	STEP :	5	3	7	2	2

PERCUSSION WITH ANTLER BILLET

		THINNING			SHAPING	
		Minimal 10i 4 flakes	Moderate 10ii 9 flakes	Subst. 11 4 flakes	Minimal 12i 10 flakes	Moderate 12ii 12 flakes
FLAKE SCAR SIZE:	V. MIN. :	1	3		9	6
	MINIMAL :	3	2		1	5
	MODERATE :		2 1	1		1
	SUBST. :		1	1		
	V. SUBST.:			2		
SHARPNESS OF PROX. EDGE:	SHARP :	4	7	4	10	12
	INTERM. :		1			
	DULL :					
PROXIMAL MARGIN DAMAGE:	ABS./RARE:					
	LIMITED :					
	MODERATE :					
	EXTENSIVE:	X	X		X	X
	V. EXT. :			X		
MICRO-FLAKES:	ABS./RARE:	X		X	X	X
	LIMITED :		X			
	MODERATE :					
	EXTENSIVE:					
	V. EXT. :					
MORPHOLOGY OF PROXIMAL EDGE:	STRAIGHT :	2½	4½		5	8
	U-NOTCH :			2		
	FL. CURVE:	2½	3½	1 1	4	2
	CONV.PROJ:					
	OTHER :				1	1
PLATFORM COLLAPSE:	N/A :		1			1
	ABSENT :	2	2		2	4
	PRESENT :	1	6	4	8	7
	PARTIAL :	1				
	UNKNOWN :					
DISTINCTIVENESS OF BULB:	NOT VIS. :	2	4	1	8	3
	INTERM. :		1	1 1	2	3
	DISTINCT :	2	2	1		4
BULB SIZE:	V. MIN. :					1
	MINIMAL :		1	1		
	MODERATE :			1	1	2
	SUBST. :	1	1	1	1	1
	V. SUBST.:	1				3

PERCUSSION WITH ANTLER BILLET, Cont'd

		THINNING			SHAPING	
		Minimal 10i 4 flakes	Moderate 10ii 9 flakes	Subst. 11 4 flakes	Minimal 12i 10 flakes	Moderate 12ii 12 flakes
RIBS: PRESENCE:	ABS./RARE:					
	LIMITED :				X	
	MODERATE :	X	X			X
	EXTENSIVE:					
	V. EXT. :			X		
RIBS: DISTINCTIVENESS:	INDIST. :	1	1	3 1		3
	MOD. DIST:	1	1 1	1 1		
	PRON. :		1		1	
	VARIABLE :					
RIBS: SPACING:	F & E :					
	F & D½ :					
	CL & E :					
	CL & D½ :	1	3	3		2
	VARIABLE :			1		
	OTHER :					
TEARING:	ABS./RARE:	X		X	X	X
	LIMITED :		X			
	MODERATE :					
	EXTENSIVE:					
	V. EXT. :					
DISTAL EDGE SHAPE:	STRAIGHT :	1			1	3
	ROUNDED :		3	3	6	6
	IRREGULAR:	3	6	1	2	3
TERMINATION:	FEATHERED:	3	1 2	3	1 5	1 8
	STEP :	1	6	1	4	3

PERCUSSION WITH COBBLE

		THINNING			SHAPING	
		Minimal 13i 7 flakes	Moderate 13ii 9 flakes	Subst. 14 3 flakes	Minimal 15i 12 flakes	Moderate 15ii 9 flakes
FLAKE SCAR SIZE:	V. MIN. :	3	3		12	3
	MINIMAL :	3	1			5
	MODERATE :	1	3			1
	SUBST. :			1		
	V. SUBST. :		2	2		
SHARPNESS OF PROX. EDGE:	SHARP :	7	9	3	12	9
	INTERM. :					
	DULL :					
PROXIMAL MARGIN DAMAGE:	ABS./RARE:					
	LIMITED :					
	MODERATE :	X	X			X
	EXTENSIVE:				X	
	V. EXT. :			X		
MICRO-FLAKES:	ABS./RARE:	X	X		X	X
	LIMITED :					
	MODERATE :			X		
	EXTENSIVE:					
	V. EXT. :					
MORPHOLOGY OF PROXIMAL EDGE:	STRAIGHT :	4½	2		5	4
	U-NOTCH :		1			
	FL. CURVE:	2½	5	3	7	4
	CONV.PROJ:					
	OTHER :					
PLATFORM COLLAPSE:	N/A :		1		1	
	ABSENT :				2	2
	PRESENT :	6	8	3	9	7
	PARTIAL :	1				
	UNKNOWN :					
DISTINCTIVENESS OF BULB:	NOT VIS. :	3	2		5	1
	INTERM. :	1			2	4
	DISTINCT :	2	4	3	4	2
BULB SIZE:	V. MIN. :					1
	MINIMAL :	1	2	1	1	
	MODERATE :		1			4
	SUBST. :			2	1	1
	V. SUBST. :	2	1		4	1

PERCUSSION WITH COBBLE, Cont'd

		THINNING			SHAPING	
		Minimal 13i 7 flakes	Moderate 13ii 9 flakes	Subst. 14 3 flakes	Minimal 15i 12 flakes	Moderate 15ii 9 flakes
RIBS: PRESENCE:	ABS./RARE:					
	LIMITED :				X	
	MODERATE :		X			
	EXTENSIVE:	X				
	V. EXT. :			X		X
RIBS: DISTINCTIVENESS:	INDIST. :					3
	MOD. DIST:	3	1	1 1	1	2
	PRON. :	1	1		1	
	VARIABLE :		1	1		
RIBS: SPACING:	F & E :		1			
	F & D½ :				1	
	CL & E :	1	1	3		5
	CL & D½ :	1	1			2
	VARIABLE :		2			
	OTHER :					
TEARING:	ABS./RARE:	X	X		X	X
	LIMITED :			X		
	MODERATE :					
	EXTENSIVE:					
	V. EXT. :					
DISTAL EDGE SHAPE:	STRAIGHT :		3		1	
	ROUNDED :	1	3	2	5	5
	IRREGULAR:	6	3	1	6	4
TERMINATION:	FEATHERED:	1 3	1 5	2	10	3 6
	STEP :	3	3	1	2	

		INDIRECT PERCUSSION THINNING		RE-SHARPENING:	EDGE PRESS ON ANVIL
		Moderate 16i 6 flakes	Substantial 16ii 3 flakes	Pressure over Pressure 20i 13 flakes	50 24 flakes
FLAKE SCAR SIZE:	V. MIN. :	2		7	24
	MINIMAL :	1		9	
	MODERATE :	1			
	SUBST. :	1			
	V. SUBST. :	1	1 2		
SHARPNESS OF PROX. EDGE:	SHARP :	6	1 2	12	22
	INTERM. :				
	DULL :				
PROXIMAL MARGIN DAMAGE:	ABS./RARE:				
	LIMITED :		X	X	
	MODERATE :				X
	EXTENSIVE:	X			
	V. EXT. :				
MICRO-FLAKES:	ABS./RARE:	X	X		
	LIMITED :		(on one artifact)		
	MODERATE :			X	
	EXTENSIVE:				X
	V. EXT. :		X (other art.)		
MORPHOLOGY OF PROXIMAL EDGE:	STRAIGHT :		1½	2	11
	U-NOTCH :				
	FL. CURVE:	1 4	1½	1 8	2 9
	CONV.PROJ:				
	OTHER :	1		1	
PLATFORM COLLAPSE:	N/A :			4	2
	ABSENT :		1	1	7
	PRESENT :	5	1	10	14
	PARTIAL :	1	1		
	UNKNOWN :				
DISTINCTIVENESS OF BULB:	NOT VIS. :		1	10	19
	INTERM. :	2		2	3
	DISTINCT :	4	2	3	
BULB SIZE:	V. MIN. :				
	MINIMAL :	1	1	3	1 1
	MODERATE :	2		1 1	1
	SUBST. :	1	1	1	
	V. SUBST. :	2	1		1

		INDIRECT PERCUSSION THINNING, Cont'd		RE-SHARPENING: Pressure over Pressure (Cont'd)	EDGE PRESS ON ANVIL (Cont'd)
		Moderate 16i 6 flakes	Substantial 16ii 3 flakes	20i 13 flakes	50 24 flakes
RIBS: PRESENCE:	ABS./RARE				
	LIMITED				
	MODERATE				X
	EXTENSIVE				
	V. EXT.	X	X	X	
RIBS: DISTINCTIVENESS:	INDIST.	1	1	4 8	2 5
	MOD. DIST	3		1	1
	PRON.	1			2
	VARIABLE	1	2		1
RIBS: SPACING:	F & E				
	F & D$\frac{1}{2}$			1	
	CL & E	2	1	6	4
	CL & D$\frac{1}{2}$	2	1	5	3
	VARIABLE	1	1	1	
	OTHER				1
TEARING:	ABS./RARE	X		X	X
	LIMITED				
	MODERATE				
	EXTENSIVE				
	V. EXT.		X		
DISTAL EDGE SHAPE:	STRAIGHT	2	1	1 2	9
	ROUNDED	1	1	1	8
	IRREGULAR	3	1	to STR: $^{10}{}_{2}$	7
TERMINATION:	FEATHERED	2 2	2	1 12	2 13
	STEP	2	1	3	9

TABLE
II-32 : COMPARATIVE RAW DATA ON ALL BEHAVIOURS AND ATTRIBUTES

		EDGE DAMAGE					PLATFORM COLLAPSE (PROXIMAL EDGE MORPHOLOGY)				RIBS													BULB OF FORCE								DISTAL SHAPE			TERMINATION	
											PRESENCE					DISTINCTIVENESS				SPACING				DISTINCTIVENESS			SIZE									
		ABS/ RARE	LIM.	MOD.	EXT.	VERY EXT.	STR.	FLAT CURVE	U-NOTCH	OTHER	ABS/ RARE	LIM.	MOD.	EXT.	VERY EXT.	IND.	MOD.	PROM	VAR.	CLOSE /EVEN	CLOSE/ DIST.½	VAR.	OTHER	NOT VIS.	INT.	DIST	VERY MIN.	MIN.	MOD.	SUB.	VERY SUB.	STR.	RD.	IRR.	FEATH.	STEP
PRESSURE	7i		1				4	4		1	½	½				1								8	1				1			3	2½	3½	4	5
	7ii			½	½			3½	½				½	½		2				1	1			2		2	½	½		1		2		2	1	3
	8		½	½			1	5	6	1				1		5	2			3	2		1	2	6	5			5	6		5½	2	5½	4½	8½
	9i			1			4	6		3		1				2					2			9	4			2	½	2	½	3	3	7	11	2
	9ii			1			1	6½	1½	1				1		3			2	3	2			3	2	4			3	½	2½	3	3	3	6	3
	20i		1				2	8½	½	1					1	10	3			6	5	1	1	10	2	3		3	1½	1½		3½	1½	11	12½	3½
	Total	0	2½	3	½	0	12	33½	8½	7	½	1½	½	2½	1	23	5	0	2	13	12	1	2	34	15	14	½	5½	11	11	3	20	12	32	39	25
PERCUSSION	10i				1		2½	2½					½	½		1	1				1			2		2				1	1	1		3	3	1
	10ii				1		4½	3½					1			1	1½	1½			3			4	1	2		1		1			3	6	2½	6½
	11					1		1½	2½						1	1½	2	½			3	1		1	1½	1½		1	1	1			3	1	3	1
	12i				1		5	4		1		1						1						8	2				1	1		1	6	3	5½	4½
	12ii				1		8	2		1			1			3					2			3	3	4	1		2	1	3	3	6	3	8½	3½
	13i			1			4½	2½						1			3	1		1	1			3	1	2		½	½		2		1	6	3½	3½
	13ii			1			2	5½	½				1			1	1	1	1	1	1	1	1	2		4		2	1		1	3	3	3	5½	3½
	14					1		2½	½						1		1½	½	1	3						3		1		2			2	1	2	1
	15i				1		5	7				1					1	1					1	5	2	4		1		1	4	1	5	6	10	2
	15ii			1			4	4							1	6	2			5	2			1	4	2	1		4	1	1		5	3	7½	1½
	16i				1			4½	½	1					1	1	3	1	1	2	2	1			2	4		1	2	1	2	2	1	3	3	3
	16ii				1		1½	1½							2	½	½		2	1	1	1		1		2		1		1	1	1	½	1½	2	1
	Total	0	0	3	7	2	37	41	4	3	0	2	3½	1½	6	15	16½	7½	5	13	16	4	2	30	16½	30½	2	8½	11½	11	15	12	35½	39½	56	32
EDGE UNITS	1i	1					9½	3	½		1								1	1				11	1	1			1		1	4½	7½	2	12	2
	1ii			1			13½	3½	1		½	½				1	1							mostly N/A		2				2		7½	6	2½	16	5
	2i			1			3½	1		½			1			1			1		1	1		4	1		1					1½	2½	1	2	3
	2ii			1			6	4½	½				1			1	2			1	1			6	2	2			1		2	2	7	3	9	3
	3i		1				15	4					1			2½	1½	1		1	3			11	3	4		2	3	2		6	11	2	15	4
	3ii				1		17	4	½	1½			1			6	4	1		8				15	5	3		3	3	2		8½	10	6½	9	16
	4i		1				13½	3½		2			1			5½	½			2	1			14	3	1		2	2½	½	1	8	8	5	14	6
	4ii				1		7½	9½		3				1		7½	3½	1		4	5		3	11	3	6		2½	3	2½	2	1½	9	10½	8½	12½
	5i	1					6	4		1			1			2	3				5			9	2			2				7.3	3.3	2.3	5½	6½
	5ii				1		14	1						1		4½	2½		1	3	4			10	1	5	1	2½	1½		1	1	10½	4½	10½	5½
	6i			1			6	6	1					1		9	1			1	6			5	3	5	1	5		2		3	5½	4½	9½	2½
	6ii				1		7	2		1					1	2½	2½		1	4	2		1	1	7	2		3	4	½	½	2	4	4	6½	3½
	50			½	½		10½	10	1½				1			6	2	2	1	4	3		1	19	3			½	1½	½	½	9	8	7	14	10
	Total	2	2	4½	4½	0	129	56	5	9	1½	½	7	3	1	48½	23½	5	5	29	31	1	5	116	34	31	3	22½	20½	12	8	61.8	92.3	54.8	131½	79½
PRESSURE			42%	50%	8%		20%	55%	14%	12%	8%	25%	8%	42%	17%	77%	17%		7%	46%	43%	4%	7%	54%	24%	22%	2%	18%	36%	36%	10%	31%	19%	50%	61%	39%
PERCUSSION				25%	58%	17%	44%	48%	5%	4%		15%	27%	12%	46%	34%	38%	17%	11%	37%	46%	11%	6%	39%	21%	40%	4%	18%	24%	23%	31%	14%	41%	45%	64%	36%
EDGE UNITS		15%	15%	35%	35%		65%	28%	3%	5%	12%	4%	54%	23%	8%	59%	29%	6%	6%	44%	47%	2%	8%	64%	19%	17%	5%	34%	32%	18%	12%	30%	44%	26%	62%	38%
		- → + press. e-u perc.					- → + e-u perc. press.				- → + e-u press. perc.					- → + press. e-u perc.				CL & E: - → + perc. e-u/ press. CL & D½: - → + press/perc/e-u				- → + e-u press perc			- → + e-u press. perc.					- → + str: perc e-u/press rd: press perc/e-u irr: e-u perc press			all mostly feathered (same %)	

Cont'd

TABLE II-32, Cont'd

		EDGE DAMAGE					PLATFORM COLLAPSE (PROXIMAL EDGE MORPHOLOGY)				RIBS													BULB OF FORCE								DISTAL SHAPE			TERMINATION	
											PRESENCE					DISTINCTIVENESS				SPACING				DISTINCTIVENESS			SIZE									
		ABS/ RARE	LIM.	MOD.	EXT.	VERY EXT.	STR.	FLAT CURVE	U-NOTCH	OTHER	ABS/ RARE	LIM.	MOD.	EXT.	VERY EXT.	IND.	MOD.	PRON	VAR.	CLOSE /EVEN	CLOSE/ DIST.½	VAR.	OTHER	NOT VIS.	INT.	DIST	VERY MIN.	MIN.	MOD.	SUB.	VERY SUB.	STR.	RD.	IRR.	FEATH.	STEP
BILLET	10i				1		2½	2½					½	½		1	1				1			2		2				1	1	1		3	3	1
	10ii				1		4½	3½					1			1	1½	1½			3			4	1	2		1		1			3	6	2½	6½
	11					1		1½	2½						1	1½	2	½			3	1		1	1½	1½		1	1	1			3	1	3	1
	12i				1		5	4		1		1						1						8	2				1	1		1	6	3	5½	4½
	12ii				1		8	2		1			1			3					2			3	3	4	1		2	1	3	3	6	3	8½	3½
	Total				4	1	20	13½	2½	2		1	2½	½	1	6½	4½	3			9	1		18	7½	9½	1	2	4	5	4	5	18	16	22½	16½
COBBLE	13i			1			4½	2½						1			3	1		1	1			3	1	2		½	½		2		1	6	3½	3½
	13ii			1			2	5½	½				1			1	1	1	1	1	1	1	1	2		4		2	1		1	3	3	3	5½	3½
	14					1		2½	½						1		1½	½	1	3						3		1		2			2	1	2	1
	15i				1		5	7				1					1	1					1	5	2	4		1		1	4	1	5	6	10	2
	15ii			1			4	4							1	6	2			5	2			1	4	2	1		4	1	1		5	3	7½	1½
	Total			3	1	1	15½	21½	1			1	1	1	2	7	8½	3½	2	10	4	1	2	11	7	15	1	4½	5½	4	8	4	16	19	28½	11½
BILLET					80%	20%	53%	36%	7%	5%		20%	50%	10%	20%	46%	32%	21%			90%	10%		51%	21%	27%	6%	13%	25%	31%	25%	13%	46%	41%	58%	42%
COBBLE				60%	20%	20%	42%	58%	2%			20%	20%	20%	40%	33%	40%	17%	10%	59%	24%	6%	12%	33%	21%	46%	4%	20%	24%	17%	35%	10%	41%	49%	71%	29%
		- → + C B					- → + B C				- → + B C					- → + B C				CL & E - → + B C CL & D½ - → + C B				- → + B C			- → + B/C					- → + str: C/B rd: C/B irr: B/C			few more feath. with the cobble	